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PHYSICS.—*The limitations of the principle of superposition.*[1]

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The principle of superposition, as applied in harmonic analysis, received its mathematical formulation at the hands of Fresnel in 1819. The conservation of energy did not come into physical thinking until the middle of the nineteenth century. In consequence, Fresnel's procedure gives rise, in some cases, to violations of the energy principle. The present article gives a study of these cases and suggests a method of handling them.

The principle of superposition dates back to Huygens (1678), but as applied in harmonic analysis it received its present accepted formulation at the hands of Fresnel in 1819.[2] According to this, the resultant of a number of simple harmonic vibrations is obtained by adding their amplitudes. This gives rise, in some cases, to a violation of the conservation of energy. For example, if we have two component vibrations, each with a periodic time of 2π seconds,

$$y_1 = \sin t \quad y_2 = \sin t \qquad (1)$$

the energy of their resultant $y = 2 \sin t$ will be twice the sum of the energies of the components. But with the components

$$y_1 = \sin t \quad y_2 = \cos t \qquad (2)$$

the resultant $y = \sin t + \cos t$ does not violate the energy principle.

In the general case of which (1) and (2) are special cases,

$$y_1 = \sin t \quad y_2 = \sin(t - \theta) \qquad (3)$$

the excess (or deficiency) of energy in the resultant is equal to $\cos \theta$. From this it will be obvious that the addition of amplitudes may be valid in only a minority of cases. (Appendix 1.)

The reason for these violations of the energy principle is that in Fresnel's day the concept of energy and its conservation had not come into physical thinking. This did not happen until the middle of the nineteenth century. In 1847 Helmholtz published a paper entitled "Die Erhaltung der Kraft," and this name "conservation of force" lingered for some years after Rankine and Sir William Thomson introduced the term "energy" about 1850. Had Fresnel lived 50 years later he would naturally have added energies instead of amplitudes. In other respects also his article shows the rudimentary character of physical thought at that time. The dimensions of physical quantities were unknown to him. There are places where he adds to a time the ratio of two lengths. What is difficult to account for is the fact that the general adoption of the conservation of energy did not bring about a critical study and recasting of his formulation of the principle of superposition; but for this there may be a reason which will be mentioned later.

There are a few references in the literature of physics to these violations of the energy principle. Of these perhaps the most important is one giving Maxwell's views on the subject. The article "Harmonic Analysis" in the eleventh edition of the Encyclopaedia Britannica was written by Horace Lamb. The initials J. C. M. are signed to the earlier part of this article. In this part we find the following:

> The harmonic method may be defined in a more general manner as a method by which the solution of any actual problem may be obtained as the sum or resultant of a number of terms,

[1] Received August 18, 1950.

[2] FRESNEL, *Mémoire couronné sur diffraction.* Oeuvres Complètes **1**: 286–293. 1819.

each of which is a solution of a particular case of the problem. The nature of these particular cases is defined by the condition that any one of them must be conjugate to any other. The mathematical test of conjugacy is that the energy of the system arising from two of the harmonics existing together is equal to the sum of the energy arising from the two harmonics taken separately.

Maxwell died in 1879, and this edition of the Britannica was published in 1910. This statement by Maxwell does not appear in any other of his published writings. He may have included it in his article years later.

Components (1) are what Maxwell would call nonconjugate, as there is an excess of energy in the resultant; but components (2) are conjugate. Maxwell does not indicate any method for handling nonconjugate functions.

The usual methods of explaining away these violations of the energy principle are statistical in nature. An example is Rayleigh's article "Wave Theory of Light."[3] In this article he recognizes and formulates the difficulty, but says that in the case of light it may be avoided by a statistical treatment. He assumes n equal sine pulses of unit amplitude, and admits that if they are all in the same phase the amplitude of the resultant sum will be n and its energy proportional to n^2; but he says, in effect, "This will never happen." In the light from a candle, as he points out, we find all possible differences of phase in rapid succession, and he shows that in such a case the mean expectancy of intensity in the resultant will be proportional not to n^2 but to n. This will always be the case with light from any of the usual sources, consisting as they do of multitudes of atomic oscillators; but when we are dealing with sound waves, where the source, if not a single oscillator, consists of but a few such oscillators, Rayleigh's statistical treatment is not applicable. For such cases the method commonly used in treatises on optics is to integrate the resultant of two sources over a sphere surrounding them. Here the statistical element is not in the number of sources, but in the number of illuminated points in the integral. The objection to all such statistical treatments is that they avoid rather than explain the fundamental difficulty, and build up a satisfactory conclusion from basic assumptions which violate the energy principle. Such procedure suggests the proverbial statue with feet of clay.

[3] Written for the Encyclopaedia Britannica in 1888 and included in Rayleigh's Collected Papers 3: 52.

Now if instead of construing the superposition principle to mean addition of amplitudes we use addition of energies the difficulty disappears; and on this basis we shall now develop a method for handling nonconjugate functions of equal frequency, such as those in (1), (2), and (3).

The difficulty in these cases can be overcome by applying modifying factors to the components before adding them. In case (1) the components are equal in energy and should therefore contribute equally to the energy of the resultant. Applying to each component the same factor M we obtain the modified components

$$y_1' = M \sin t \qquad y_2' = M \sin t$$

which by addition give the resultant $y = 2M \sin t$, whose energy is $2M^2$. This should equal the sum of the energies of the original components. We have then $2M^2 = 1$, giving $M = 2^{-\frac{1}{2}}$.

In case (2) there is no excess energy in the resultant sum. No modification is needed, and the factors come out unity.

In case (3) the factors come out $(1 + \cos \theta)^{-\frac{1}{2}}$. When $\theta = 0$ this equals $2^{-\frac{1}{2}}$ as in (1); and when $\theta = 90°$ the factors become unity, as in case (2). (Appendix 2.)

So much for components of equal frequency. For different frequencies different modifying factors are required. The mathematical analysis of such cases is quite intricate, and may be made the subject of a later paper.

With more than two or three components of different frequencies the mathematical labor involved rapidly mounts up; but fortunately it happens that in a number of cases of practical importance we can employ the traditional incorrect method and still obtain a correct result. Probably it is this curious fact which has long delayed the recognition of the limitations of the principle of superposition.

For example, take tide prediction. The first thing to do is to obtain an experimental curve for the port. This is then analyzed harmonically, using the traditional method of superposition. The components thus obtained are synthesized by the traditional method after certain corrections are applied, and a resultant curve is thus obtained for some years ahead.

Now what happens here is that the components obtained by analysis of the experimental curve are what we may call artificial components—smaller than the real physical components. On reversing the process and synthesizing these artificial components by adding amplitudes we reverse the error previously committed and obtain a correct result. In cases like this it makes no difference whether we do or do not use modifying factors. It is of importance, however, that textbooks should state the correct fundamental theory of the subject.

In the present paper we have considered only vibrations of a particle. There are other applications of the superposition principle which the writer has investigated, and it may be sufficient for the present to sum up the conclusions.

In wave motion, similarly running waves are nonconjugate functions; but with equal and oppositely running waves, generating a standing wave, there is no violation of the conservation of energy.

With alternating currents the addition of amplitudes is valid in all cases, as is indicated by laboratory experiment. An alternating current and a simple harmonic vibration can both be expressed by the same graph—a sine curve; but with the shape of the graph the parallelism stops. The vibrating particle has constant energy at all instants of time, while the energy of the current is zero when either the current or the voltage is zero. In consequence, the energy laws in the two cases are different.

Appendix 1

Consider the general case of components (3). For a vibrating element of unit mass each component will have an energy of $\frac{1}{2}$, and the sum of the component energies will be unity. The resultant sum will be $y = \sin t + \sin(t - \theta)$, and its second derivative $d^2y/dt^2 = -y$ will be the force of restitution.

$$\text{Potential energy} = \int_0^y y\,dy = \tfrac{1}{2}y^2$$

$$= \tfrac{1}{2}\sin^2 t + \tfrac{1}{2}\sin^2(t-\theta) + \sin t \sin(t-\theta)$$

$$\text{Kinetic energy} = \frac{1}{2}\left(\frac{dy}{dt}\right)^2$$

$$= \tfrac{1}{2}\cos^2 t + \tfrac{1}{2}\cos^2(t-\theta) + \cos t \cos(t-\theta)$$

$$\text{Energy sum} = \tfrac{1}{2} + \tfrac{1}{2} + \cos[t - (t-\theta)]$$

$$= 1 + \cos\theta$$

Excess energy in resultant sum = $\cos\theta$. When $\theta = 0$, as in component (1), the excess energy equals unity; and when $\theta = -\pi/2$, as in component (2), the excess equals zero.

Appendix 2

Consider case (3), where the components are equal in energy.

$$y_1 = \sin t \qquad y_2 = \sin(t-\theta)$$

Applying equal factors M, we obtain the modified components

$$y_1' = M\sin t \qquad y_2' = M\sin(t-\theta)$$

whose resultant sum is

$$y = M[\sin t + \sin(t-\theta)]$$

Kinetic energy of resultant

$$= \tfrac{1}{2}M^2[\cos^2 t + \cos^2(t-\theta) + 2\cos t\cos(t-\theta)]$$

Potential energy = $\frac{1}{2}M^2y^2$

$$= \tfrac{1}{2}M^2[\sin^2 t + \sin^2(t-\theta) + 2\sin t\sin(t-\theta)]$$

Energy sum

$$= \tfrac{1}{2}M^2[1 + 1 + 2\cos(t - (t-\theta)]$$

$$= M^2[1 + \cos\theta)$$

This should equal the energy sum of the original components.

$$M^2(1 + \cos\theta) = 1$$

$$M = (1 + \cos\theta)^{-\frac{1}{2}}$$

When $\theta = -\pi/2$ components (3) reduce to (2), and $M = 1$; and when $\theta = 0$, $M = 2^{-\frac{1}{2}}$ as in (1).

METEOROLOGY.—*The trend in temperature at Washington, D.C., for 1862–1949.*[1] RICHMOND T. ZOCH.

AVAILABLE DATA

There are published records of instrumental observations of temperature for Washington, D.C., beginning with 1817. However, a careful examination of the early records shows that little is known about the exposure of instruments or the rules used for taking and recording the observations. The late Dr. C. F. Marvin[2] once stated: "A true normal daily temperature can be computed with entirely sufficient accuracy only from a long series of values of 24 hourly temperatures for each day." If this statement is taken literally, then only two series of temperature observations are available in or near Washington, viz (1) the U. S. Weather Bureau Airport record of hourly observations beginning in 1928 and with the location of instruments in three different places since the beginning of the record; and (2) the U. S. Weather Bureau record at 24th and M Streets, NW., which began in March 1889.

A good approximation to 24 hourly temperatures for each day is given by three hourly observations. Beginning about 1840 the U. S. Naval Observatory made readings of the thermometer every three hours at its old location at 24th and E Streets, NW. These observations continued until 1892 when the Naval Observatory was moved to its present location on Massachusetts Avenue. At first it would seem that by supplementing the 24th and M Streets observation of the Weather Bureau with the 24th and E Streets record of the Naval Observatory that a total record length of more than 100 years (from about 1840 to date) would be available for studying the trend in temperature at Washington. It is true that these early temperature observations of the Naval Observatory are available for study, but according to J. R. Eastman,[3] for many years a member of the staff of the U. S. Naval Observatory, reliable observations by that institution did not begin until 1862. Because of this statement it was thought best to confine the Naval Observatory record used in this study to the period 1862–1892. It is believed that the record from 1862 to 1892 was one of the best, if not the best, records of temperature maintained in the District of Columbia up to and including that period. The observations were taken at the same location, by the same group of observers, with but few changes in the thermometers and, moreover, during this 31-year period the observers were under the supervision of the same man, viz, J. R. Eastman. This combination of circumstances is rather unusual to be maintained for such a long period of time, and so can be regarded as a quite homogeneous record.

ANALYSIS OF THE DATA

It will be noted that simultaneous records are available for four years, 1889–1892, at these two locations. The first step in analyzing the data was to compare the daily means computed from eight observations at 24th and E Streets, NW., with the means computed from 24 observations at 24th and M Streets, NW., for this 4-year period. It was found that there were differences and when these differences were tested for statistical significance they were found to be significant. The results of this comparison are given in Table 1.

Next, the records at the 24th and E Streets location were adjusted to make them comparable with the 24th and M Streets location. By making this adjustment it can be

TABLE 1.—COMPARISON OF DAILY TEMPERATURES AT 24TH AND M STREETS WITH 24TH AND E STREETS, 1889–1892

(Note: A minus sign means that 24th and E Streets is colder.)

Month	Number of observations	Average daily difference	Month	Number of observations	Average daily difference
		°F			°F.
January	124	−1.15	July	124	−0.01
February	113	−0.69	August	124	+0.20
March	124	−0.51	September	120	+0.48
April	120	−0.63	October	124	−0.10
May	124	−0.29	November	120	−0.58
June	120	−0.22	December	124	−1.05

[1] Received September 14, 1950.

[2] Monthly Weather Rev. Suppl. 25: 1. 1925.

[3] Washington Astronomical and Meteorological Observations for the year 1866: Appendix 1, p. 2.

considered that 87 years of comparable records, viz, from March 1862 to March 1949, are available for a study of trend.

A quick analysis of the annual means of temperature will show that any observed trend in temperature, even though significant, is small. The question arises whether both positive and negative trends will be observed if the year is divided into a number of parts. Accordingly, the year was divided into 36 periods of 10 or 11 days each, three periods for each month (roughly) and means of temperature were computed for each period and for each year. These decade mean temperatures are available, but to save space they are not tabulated here.

A regression coefficient was then computed for each decade to ascertain whether there was any relation between temperatures and time. The results of these computations are given in Table 2.

Statisticians have devised tests to apply to regression coefficients in order to determine if the observed trend could have been

TABLE 2.—ANALYSIS OF TREND IN TEMPERATURE

Period	Length of period	Average temperature for 87-year period	Trend °F. per annum (Regression coefficient)	Results of test for significance
	days	°F.		
Mar. 21-30	10	46.20	+0.1090	Significant at 99-percent level.
Mar. 31-Apr. 9	10	49.72	+0.0689	Do.
Apr. 10-20	11	53.17	+0.0436	Significant at 95-percent level.
Apr. 21-30	10	57.23	+0.0298	Not significant
May 1-10	10	60.99	+0.0550	Significant at 99-percent level.
May 11-21	11	64.20	+0.0392	Significant at 95-percent level.
May 22-31	10	66.71	+0.0309	Not significant
June 1-10	10	70.07	+0.0356	Significant at 95-percent level.
June 11-21	11	72.27	+0.0314	Not significant
June 22-Jul. 1	10	74.91	+0.0210	Do.
Jul. 2-11	10	76.05	+0.0044	Do.
Jul. 12-22	11	76.63	+0.0114	Do.
Jul. 23-Aug. 1	10	76.36	+0.0402	Significant at 99-percent level.
Aug. 2-11	10	76.04	+0.0246	Not significant
Aug. 12-22	11	74.41	+0.0187	Do.
Aug. 23-Sep. 1	10	72.38	+0.0262	Do.
Sep. 2-11	10	71.34	+0.0449	Significant at 99-percent level.
Sep. 12-22	11	67.86	+0.0394	Do.
Sep. 23-Oct. 2	10	63.56	+0.0128	Not significant
Oct. 3-12	10	59.76	+0.0325	Do.
Oct. 13-22	10	56.59	+0.0472	Significant at 99-percent level.
Oct. 23-Nov. 1	10	52.49	+0.0654	Do.
Nov. 2-11	10	49.15	+0.0610	Do.
Nov. 12-21	10	45.65	+0.0505	Do.
Nov. 22-Dec. 1	10	41.61	+0.0460	Significant at 95-percent level.
Dec. 2-11	10	38.46	+0.0460	Do.
Dec. 12-21	10	35.82	+0.0309	Not significant
Dec. 22-31	10	34.99	+0.0281	Do.
Jan. 1-10	10	34.16	+0.0793	Significant at 99-percent level.
Jan. 11-20	10	34.11	+0.0586	Significant at 95-percent level.
Jan. 21-30	10	34.11	+0.0120	Not significant
Jan. 31-Feb. 9	10	33.11	+0.0280	Do.
Feb. 10-19	10	35.50	+0.0313	Do.
Feb. 20-29	10	37.28	+0.0319	Do.
Mar. 1-10	10	39.66	+0.0419	Do.
Mar. 11-20	10	43.48	+0.0719	Significant at 99-percent level.

caused by chance. The results of these tests can be expressed by the degree of confidence, and this is shown in the last column of Table 2.

CONCLUSIONS

The tests of significance show that 12 of the regression coefficients are significant at the 99-percent level, 6 at the 95-percent level, while the remaining 18 were not significant. However, perhaps the outstanding result of these computations is that *all* 36 regression coefficients were positive. It can be concluded that the climate of Washington has been getting warmer.

It will be noted from Table 2 that the warmest half of the year is from April 22 to October 22. The average trend for this half is 0.0303° per annum. The average trend for the colder half is 0.0501° F. per annum. In the winter half four decades are significant at the 95-percent level and 7 at the 99-percent level. In the summer half only two decades are significant at the 95-percent level and only 5 at the 99-percent level.

It will also be noted from Table 2 that the warmest quarter of the year is from June 11 to September 11 for which the average temperature over this period of record was 74.49°F., and the coldest quarter is from December 2 to February 29 for which the average temperature was 35.28°F. Such a division makes the spring season two decades longer than the autumn season and if the year be divided into four seasons of nine decades each the following results are obtained:

Season	*Period*	*Average Temperature °F.*	*Average Trend °F. per annum*
Winter	Dec. 2-Feb. 29	35.28	0.0381
Spring	Mar. 1-May 31	53.48	0.0545
Summer	June 1-Sept. 1	74.35	0.0237
Autumn	Sept. 2-Dec. 1	56.45	0.0444

This study was based on data for the 87-year period ending March 21, 1949. The observed temperature for the year since this date tends strongly to verify the trend computed for the 87 years.

Acknowledgment—The writer is indebted to Robert F. Dale, of the U. S. Weather Bureau, for his advice and encouragement while this paper was prepared.

ARCHEOLOGY.—*An analysis and interpretation of the ceramic remains from site 38Mc6*[1] *near Clarks Hill, S. C.*[2] CARL F. MILLER, River Basin Surveys, Bureau of American Ethnology.

The pottery described in this report was obtained from a deeply buried site by the U. S. Corps of Engineers while widening the channel of the Savannah River prior to the construction of the Clarks Hill dam. The widening necessitated the removal of 250 feet of soil from the east bank of the river, upon which the main portion of the site was located.

The dam, now under construction, is located about 22 miles upstream from Augusta, Ga., near the southeastern margin of the Piedmont Plateau region of Georgia-South Carolina and about 20 miles above the "fall line." The topography of the reservoir area is typical of the eastern Piedmont.

The site is located on the immediate banks of the Savannah River opposite Clarks Hill, S. C., in the direct line of the main axis of the dam. The cultural deposit lies in the center of the site beneath 3.5 feet of clean, sterile river-deposited sand and silt, and resembles a shallow bowl in that the deposit gradually slopes upward to within a foot of the present surface. The cultural layer varies in thickness from 12 to 19 inches and is composed of a bluish-gray muck, containing the various artifacts. This deposit extends along the river bank for about 450 feet.

From the general appearance and nature of the deposit, it is surmised that the Indian inhabitants lived in an old slough. Whether they constructed some sort of pile dwellings

[1] Site designation used is trinomial in accordance with River Basin Surveys' methods in other areas. The first element, a number, indicates the State's numerical position in an alphabetical list of States, as 38 for South Carolina; the second, two letters, indicates the county symbol, as "Mc" for McCormick; the third is the number of the site within the series in that county.

[2] Published by permission of the Secretary, Smithsonian Institution. Received September 21, 1950.

cannot be determined, but the presence of such dwellings would explain the occurrence of artifacts within a slough-like deposit. When the site was gone over with a scraper a number of darkened circles appeared containing ash, unburned bones, potsherds, stone chips, and broken stones.[3] It was from these circles that most of the material for the present study was recovered.

A 6-foot square test pit was dug well into the undisturbed subsoil. It was noted that the upper portions of the muck deposit contained no artifacts or practically none to speak of. All the artifacts recovered came from the lower 4 to 6 inches of the deposit. It appears that the artifacts, as they were discarded and thrown into the slough, settled into the ooze and came to rest directly upon the clay subsoil. The material from the test pit was kept separate and used as a check on the material turned over to the Survey by the U. S. Engineers. There is no evidence of stratigraphy at the site, as all the sherds were in a compact layer at the bottom of the muck deposit.

Artifacts. An examination of the material recovered from the test pit shows the following traits:

POTTERY:

Plain	42
Lamar Complicated Stamped	15
Savannah Complicated Stamped	5
Etowah Complicated Stamped	6
Clarks Hill Complicated Stamped	1
Indeterminate	5

OTHER ARTIFACTS

Stone discoidal, quartz, smoothed	1
Hammerstone, quartz	1
Projectile point, small, quartz triangular	1
Projectile point, pointed base, quartz	1
Steatite pot fragment	1

The material turned over to the Survey by the U. S. Engineers shows the following traits, all ceramic:

POTTERY:

Plain	511
Etowah Complicated Stamped	103
Savannah Complicated Stamped	28
Lamar Complicated Stamped	25
Savannah Check Stamped, Hollywood variant	25
Etowah Filfot Stamped	20
Clarks Hill Corncob Impressed	8
Clarks Hill Broad Line Stamped	3
Woodstock Linear Complicated Stamped	1
Deptford Linear Check Stamped	1
Clarks Hill Complicated Stamped	18
Indistinct	275
Indeterminate	18
Unidentified Check Stamped	7

OTHER ARTIFACTS:

Steatite fragments	3
Celt, greenstone, fragmentary	2
Hammerstone, quartz	2
Atlatl weight, winged type, frag.	1
Discoidal, stone, crude, quartz	1
Discoidal, stone smoothed, quartz	1
Projectile point, pointed base, quartz	4
Projectile point, square base, chert, crude	5
Projectile point, triangular base, quartz, small	3
Projectile point, ovate base, quartz, crude	2
Drill, ovate base, quartz	1
Graver, quartz	1
Awl, bone, fragmentary, bird	1

It is assumed that the 1,107 sherds upon which this report is based are representative of the whole deposit of the site. Though somewhat diverse in surface treatment, the pottery is rather homogeneous in paste, temper, color, and surface finish. It belongs to the sand-tempered ware which is representative of the latest ceramic horizon for this region, including the coastal part of South Carolina and Georgia and the interior of Georgia (Caldwell and McCann, 1941; Heye, Hodge, and Pepper, 1918; Kelly, 1938; Wauchope, 1948).

Varying amounts of sand were used as a binder in the clay, and the smoothness of the paste depends on the proportion of temper used. More sherds show that the matrix is evenly grained, well blended, and evenly fired than that a large amount of binder was used in an uneven blend. Occasional sherds have a dark core denoting uneven or incomplete firing, but as a rule the heat had been driven completely through the walls of the vessel. Fire clouds are very prevalent.

No handles of any description have been found at Clarks Hill. This characteristic deviates from that noted at other late sites, where strap handles were rather noticeable.

The elaborate rims encountered in the Lamar Complicated Stamped and in some of

[3] Information for this statement was furnished by Malcolm Bascom, a member of the U.S. Engineer staff, who operated the scraper over the site.

the Etowah Complicated Stamped sherds at the Lamar and Etowah sites are absent here. Most lips are simple, either rounded or flattened. No painted ware was noted.

A number of aberrant pottery types, which have not heretofore been reported upon, were noted at this site. Among these are "corncob"-impressed sherds which are also decorated with a very large, complicated, curvilinear stamped design, apparently a direct outgrowth of Swift Creek stamping (Fig. 1, *f–g*). In most cases, the corncob impression covers the neck and shoulder area of the vessel, with the stamped design blending in and apparently covering the rest of the vessel. The use of the corncob impression together with a complicated stamped design is unique. It is suggested that this type be called *Clarks Hill Complicated Stamped*.

In another instance the corncob impression covers the shoulder area and comes within a half inch of the lip, leaving the rest of the vessel plain (Fig. 1, *c*). In still another example, the corncob was rolled over the vessel exterior and then an attempt was made to obliterate the impression after the vessel had dried. Some sort of a rubbing tool was applied to the exterior in a haphazard manner leaving a series of diagonal and horizontal channels. These shallow channels do not cover the entire exterior and as a consequence small "islands" of corncob impressions are found, surrounded by semi-polished rubbing lanes. Where nothing but the corncob impression is used upon a plain base, it is suggested that the type be called *Clarks Hill Corncob Impressed* (Fig. 1, *c*).

A number of sherds have decoration resembling some of that from the Etowah mound (Ashley, 1932, fig. 82, *c*, *d*). No rim sections were found, but the decoration consists of a series of broad parallel lines interlaced with another set of parallel lines running at right angles to the first set and giving the whole a "basket-weave effect." This basket-weave effect appears on the exterior of rounded bottom, wide-mouthed jars. It is suggested that the type be designated *Clarks Hill Broad Line Stamped* (Fig. 1, *d*).

The paste of these aberrant sherds is more homogeneous than in most other specimens, being finer in texture and more compact. The clay in most cases has been well fired, in that the exterior and interior walls as well as the core, are of the same general color, a light buff. In a few instances the cores are black, showing the incomplete firing which occurs wherever firing clouds appear and the smudge is driven into the walls, causing the core to become darkened.

The exterior was roughly smoothed prior to stamping; it is rather rough and there are a number of holes formed as the vessel was being fashioned. The interior surface is well smoothed and all smoothing marks have been obliterated, leaving a fairly uniform surface. A number of firing clouds appear only on the interior of the sherds.

In the debris, a number of burned clay fragments, known as briquettes, were found, showing the impressions of small branches. The occurrence of briquettes suggests the presence of wattle and daub structures, which were common throughout the Southeast.

Conclusions.—Sites like the Clarks Hill site are usually thought of as falling within the last two of Georgia's aboriginal cultural periods, namely the Savannah II and Irene or Etowah, with the greatest stress on the last. In other words, this site is late prehistoric and early historic in time, and can be dated ca. 1540.

At the time of our visit, there was no evidence of any mound on the site. This in itself sets the site apart from the usual pattern noted for such sites as Irene, Lamar, and Etowah.

Nevertheless, the main decorative impetus seems to have come from the Etowah drainage and not from the Irene or Macon areas. A predominance of Etowah decorative motifs, shapes, and rim treatments is evident. Thus, the cultural trend was apparently down the river instead of in the opposite direction. Further investigations should be made along the upper reaches of the Savannah and Broad Rivers in order to test this hypothesis.

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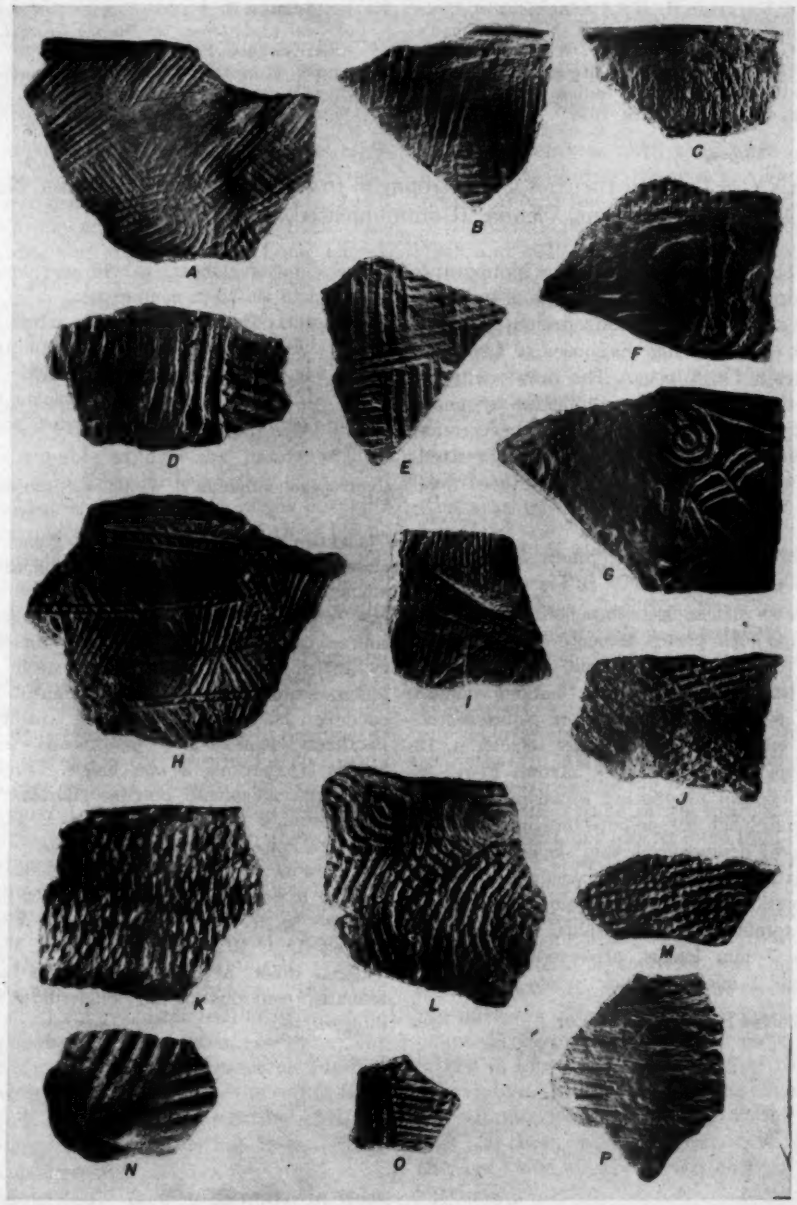

FIG. 1.—Pottery types from the Clarks Hill site, McCormick County, S. C.: *a*, Etowah Filfot Stamped; *b* and *e*, Savannah Straight Line Stamped; *c*, Clarks Hill Corncob Impressed; *d*, Clarks Hill Broad Line Stamped; *f* and *g*, Clarks Hill Complicated Stamped; *h*, Etowah Complicated Stamped; *i*, Simple Stamped; *j*, Savannah Check Stamped, Hollywood variant; *k*, fabric impressed; *l*, Savannah Complicated Stamped; *m*, Etowah Check Stamped; *n*, Deptford Linear Check Stamped; *o*, Woodstock Linear Complicated Stamped; *p*, brushed.

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BOTANY.—*Two new varieties of* Centropogon *from Colombia.*[1] E. WIMMER, Naturhistorisches Museum, Vienna. (Communicated by E. P. Killip.)

Dr. E. Wimmer, author of the monograph of Campanulaceae now in course of publication as a part of Das Pflanzenreich, has submitted the following diagnoses of two new varieties of *Centropogon.* The material upon which these are based was collected by members of the staff of the Facultad de Agronomía, Medellín, Colombia, and was submitted to Dr. Wimmer by the United States National Museum.—E.P.K.

Centropogon glaucotomentosus E. Wimm. var. **correana** E. Wimm.

Frutex scandens ozotrichus floribus aurantiacis. Superiores partes tomento plus minusve denso ferrugineo-virenti tectae. Folia elliptica, apice basique subacuminata, margine minute callose denticulata, supra demum glabrescentia, subtus imprimis in nervis dense tomentosa, 12 cm longa et 5 cm lata et minora. Flores in axillis foliorum superiorum solitarii. Pedunculi 40–45 mm longi, basi minute bibracteolati. Hypanthium depresso-globosum laciniis anguste lanceolatis 18 mm longis et in medio 2 mm latis subpatentibus. Corolla ca. 35 mm longa. Tubus filamentorum breviter pilosulus. Tubus antherarum 7 mm longus, atro-coeruleus, glaber, antherae 2 inferiores apice piloso-penicillatae. Bacca depresso-globosa, ca. 10 mm longa et 17 mm lata (in statu compresso).

COLOMBIA: Dept. Antioquia, en selvas humidas y abiertas cerca San José de San Andres, 1.5.1948 lg. *J. Correa & M. Velásquez* 34—typus hb. Wien, Wash. Varietas differt a planta typica tomento parum leviore et minus glauco, antheris glabris.

Centropogon vulpinus E. Wimm. var. **sonsonensis** E. Wimm.

Planta tomento tenui tecta, folia supra glabrescentia. Pili ramosi. Lamina foliorum oblonga vel parum obovato-oblonga, apice acuta, basi angustata, margine callose denticulata, subtus in nervis lateralibus brevi-tomentella, ca. 15 cm longa et 4 cm lata. Flores in axillis foliorum superiorum solitarii. Pedunculi 50–60 cm longi, basi 2 bracteolis parvis praediti. Hypanthium depresso-globosum lacinis triangularibus integerrimis 3 mm longis. Corolla 40 mm longa. Filamenta breviter pilosula. Tubus antherarum 6 mm longus, glaber, 2 inferiores antherae apice barbatae.

COLOMBIA: Dept. Antioquia, en chaparrál de páramo 10 km al norte de Sonsón, 2750 m s.m., 6.3.1948 lg. *G. Gutierrez, J. Correa & F. A. Barkley* 18 C 219—typus hb. Wien, Wash.—Varietas differt a planta typica follis basi attenuatis, pedicellis parum longioribus, sepalis integerrimis.

[1] Received September 28, 1950.

BIOLOGY.—*Reactions of the golden nematode of potatoes,* Heterodera rostochiensis *Wollenweber, to controlled temperatures and to attempted control measures.*[1] JULIUS FELDMESSER and GEORGE FASSULIOTIS, Bureau of Plant Industry, Soils, and Agricultural Engineering. (Communicated by G. Steiner.)

The golden nematode, *Heterodera rostochiensis* Wollenweber, 1923, has long been known to cause damage to potatoes in northern Europe and in the British Isles. This nematode was discovered on Long Island, N. Y., in 1941 and at the present time it appears that this is the only infected area in the United States. Since 1941 the basic biology of this potato pest and various methods of control have been under investigation.

The present study is concerned only with cysts (i.e., dead females containing viable larvae capable of infecting potato plants) and (1) differences in their resistance to control measures, (2) inhibition of the hatching of their larvae, (3) hatching of their larvae at controlled temperatures, (4) overwintering as a factor in the life-cycle of the nematode, and (5) hatching of their larvae during winter.

It has long been known that "summer cysts" of the golden nematode (i.e., cysts collected during the summer season) differed from "winter cysts" (collected during the winter season) in their resistance to control measures, such as hot-water treatment. A more careful study of these differences was occasioned in December 1949 when, in cooperation with the Division of Foreign Plant Quarantines of the U. S. Department of Agriculture, an attempt was made to find suitable treatment for frozen shipments of lily-of-the-valley pips containing cysts of *H. rostochiensis,* being imported from the West Zone of Germany. Full results of these investigations will be published elsewhere. The present study, however, concerns summer and winter cysts taken from the soil of Long Island, N. Y., put through treating schedules to determine whether or not they differed in reactions to treatments.

Prior to 1947, B. G. Chitwood, in work conducted on Long Island, had washed cysts from soil for winter use during the previous summers. These cysts were maintained at room temperature until they were used in experiments during the winter. The same procedure was followed by the senior author of the present study during the winters 1947–1948 and 1949–1950 with one modification: the cysts were maintained at 70°F. in a constant-temperature chamber until the time they were used. Therefore when the treating schedule was started in December 1949, a supply of summer cysts was on hand. To secure the winter cysts, infected soil was removed from a field at Hicksville during the week of December 5, 1949, and allowed to thaw out in an unheated shed. The cysts were washed out of the soil through a U.S. Standard no. 60 sieve out-of-doors and transferred immediately to the laboratory refrigerator set at 40°F. Cysts of both categories were removed from their respective chambers immediately prior to being treated.

Cysts of each type, summer and winter, in one gram lots contained in small nylon bags, were exposed to hot water in a thermoregulator-equipped hot water bath, and to methyl bromide in a fumigation chamber. The bags exposed to hot water were pre-wet to insure the escape of air from them and were immersed in water at room temperature immediately after the exposure periods. After treatment, each lot of cysts was divided into two parts and examined for viability at periods varying from three to four weeks later. One half of each lot was examined under a binocular dissecting microscope and the numbers of viable and non-viable cysts counted, the presence of one or more viable larvae in any cyst indicating that the cyst was viable. The second half was exposed to the stimulatory effect of potato root leachings (O'Brien and Prentice, 1931) and checked twice weekly for evidences of larval hatching.

The two categories of cysts showed different reactions to control measures, the winter cysts exhibiting a greater resistance to various types of control measures than the summer cysts. Triffitt and Hurst (1935) state that exposures to water at 116°F. for

[1] Report of a study made under the Research and Marketing Act of 1946. Received September 13, 1950.

45 minutes, 118°F. for 30 minutes and 130°F. for 5 minutes are lethal to the contents of the cysts of *H. rostochiensis*. In the present study, however, 116°F. for 45 minutes is a borderline treatment: two replications contained viable cysts of both categories after a two week exposure to leachings and two replications contained no viable cysts. The winter cysts show greater resistance to methyl bromide fumigation also, based on a thirty percent viability in the controls. An average of 23.8 percent of the winter cysts remained viable after exposures of four hours to four pounds per one thousand cubic feet of methyl bromide at normal atmospheric pressure and at 15 and 27 inches of vacuum. This represents a 20.7 percent kill of the formerly viable cysts. On the other hand, an average of 2.6 percent of the summer cysts remained viable when exposed to the same treatments, the kill, when compared to the control, being 91.3 percent.

This wide divergence in efficacy suggests one of the possible reasons why soil fumigation for the control of cyst-forming nematodes is more effective when applied immediately after a late summer or early autumn harvest, rather than in the spring before planting. Nematode cysts are in the summer condition late in summer and early in autumn and are more susceptible to soil treatments at that time. It is suggested that the proportionate increase of bound water within the larval protoplasm (at the expense of the free water), a device that Payne (1927a, 1927b, 1928), Robinson (1928), and Saccharov (1930) have shown to be a factor in the survival of insects at low temperatures, may be involved here. *Synchroa punctata* Newman and *Popillia japonica* Newman have been shown to be less susceptible to both extremes of temperature when most of their free water has been lost.

INHIBITION OF LARVAL HATCHING

Since golden-nematode cysts varied in their reactions to control measures, it was decided to investigate the effects, if any, of these treatments on the ability of larvae to hatch out of cysts. A search of the literature showed instances of inhibition of the hatching reaction of larvae of *H. rostochiensis* contained within the cysts. Carroll (1933) showed that exposure of cysts for two weeks to 1:100 and 1:250 parts of urea afterward resulted in complete inhibition of hatching. A 2-week delay resulted from exposure to 1:1000 parts. Hurst and Triffitt (1935) and Carroll and MacMahon (1937) found that ferric oxide added to potato root leachings delayed hatching. O'Brien and Gemmell, Prentice, Wylie (1939) state that a calcium chloroacetate treatment afterwards caused considerable delay in hatching. Smedley (1939) found that exposure of samples of one hundred cysts each to fumes of phenyl, ethyl or n-butyl isothiocyanate for 24 hours was sufficient to prevent hatching in potato root leachings afterwards for a period of two months; that exposure of samples to a 0.004 percent solution of ethyl isothiocyanate inhibited hatching for six weeks; and that the exposure of samples to 0.004 percent and 0.001-percent solutions of n-butyl isothiocyanate resulted in 24 larvae hatching after the 0.004 percent and 300 after the 0.001 percent. In the untreated control 8,500 larvae hatched out.

Cysts of both categories, winter and summer, used to check the efficacy of 4 pounds of methyl bromide per 1,000 cubic feet for four hours as a means of control were used in the present investigation. Cysts were treated on three separate occasions, and altogether seven treated lots were checked. Examinations for indications of viability were made in two ways: visually, under the binocular dissecting microscope, and by examining dishes containing treated cysts and potato-root leachings for the presence of hatched-out larvae.

With the aid of the binocular dissecting microscope, viable larvae were judged to be present in cysts of all of the treated lots. Untreated controls contained hatched-out larvae after 24 hours. Dishes containing cysts from three of the lots contained hatched-out larvae after a 1- to 2-week exposure to the stimulatory effect of potato-root leachings. Dishes containing cysts from the other four lots, however, did not contain hatched-out larvae in the same period. These cysts were then cut open in the leachings and viable larvae were found. These larvae exhibited motility when stroked with the shaft of a fine needle in the region of the circum-esoph-

ageal nerve ring. No explanation for these differing responses to potato-root leachings can be made at this time.

The results obtained with nematode cysts treated with four pounds of methyl bromide per 1,000 cubic feet for four hours indicate the existence of a period of inhibition of from one to two weeks after exposure to leachings. However, these cysts were exposed to leachings at periods varying from three to four weeks after treatment. Therefore, the total period of post-treatment inhibition may be longer when cysts are exposed to potato root leachings immediately after treatment.

It is possible that a revision of screening techniques for nematocides is in order. The absence of hatched-out larvae in treated material exposed to leachings at periods long enough to allow hatching in the controls cannot be considered as a definite indication of killing properties.

HATCHING AT CONTROLLED TEMPERATURES

There are several indications in the literature of the interrelations of temperature and the ability of *Heterodera* sp. larvae to hatch from cysts. Baunacke (1922) established two low temperature limits for the escape of larvae from cysts of *Heterodera schachtii* Schmidt: 10°C. for the escape of those that have hatched within the cyst and 18°C. for larvae that have to free themselves from their egg cases before they can escape from the cyst. These latter, according to the author, are not capable of movement as energetic as the former. Triffitt (1930), working with *H. rostochiensis* cysts that had been air-dried and stored in an unheated shed, concluded that a period of dormancy exists in the winter months during which time the larvae "will not hatch even under optimum conditions of temperature and moisture and in the proximity of potato root excretions." Miles (1930), in a study of "potato sickness" under field conditions associated intensity of root invasion with soil temperatures of 59°F. to 60°F. Since two categories of *H. rostochiensis* cysts, winter cysts and summer cysts, exist as far as resistance to hot water and methyl bromide treatments are concerned and since both categories show hatching responses to potato root leachings, it was decided to expose both categories to varying temperatures in leachings and in tap water to determine differences, if any, in hatching responses.

One gram lots of cysts, each containing approximately 300 viable cysts, were immersed in potato root leachings and in tap water in petri dishes at the following temperatures: 40°F., 50°F., 70°F., 80°F., and 100°F. The dishes were maintained at these temperatures for 16 hours in constant temperature chambers. At the end of the 16-hour period, the hatched larvae were separated from the cysts through a U.S. Standard no. 100 sieve and counted under the binocular dissecting microscope. The results are shown in Table 1.

The average numbers of hatched larvae from summer cysts show a significantly higher response, both to tap water and to potato-root leachings, at all temperatures.

TABLE 1.—NUMBER OF HETERODERA ROSTOCHIENSIS LARVAE HATCHING AT CONTROLLED TEMPERATURES DURING A 16-HOUR PERIOD IN TAP WATER AND IN POTATO ROOT LEACHINGS

Rep. No.	Summer cysts		Winter cysts	
	Tap water	Leachings	Tap water	Leachings
40°F				
A	33	31	4	5
B	55	25	3	9
C	38	20	4	7
Aver.	41.6	25.3	3.8	7.0
50°F				
A	53	41	6	1
B	47	30	20	3
C	33	54	8	3
Aver.	44.3	41.7	11.3	2.3
70°F				
A	109	205	4	7
B	113	188	2	4
C	110	201	1	6
Aver.	110.7	198.3	2.3	5.7
80°F				
A	53	131	3	9
B	60	83	1	14
C	73	95	4	9
Aver.	62.0	104.7	2.7	10.7
100°F				
A	54	40	3	13
B	40	47	0	2
C	44	44	3	3
Aver.	46.0	43.7	2.0	6.0

The stimulatory effects of tap water seem to be as marked as those of the potato root leachings at 40°F., 50°F., and 100°F. At the temperatures more commonly associated with the height of the growing season, however, potato root leachings do show a greater effect. The averages of the winter cysts show uniformly lower hatching responses at all of the temperatures both in potato-root leachings and in tap water.

A search of the literature dealing with dormancy in the invertebrates indicates that experimental work, thus far has been restricted largely to the insects. Payne (1927a, 1927b, 1928) found that survival of *Synchroa punctata* Newman at freezing temperatures is associated with the organism's ability to undergo dehydration. She specifies that the dehydration involves the loss of free water only. Cold hardiness was produced by experimental dehydration of individuals to half their body weights. Such individuals survived temperatures as low as −28°C. Robinson (1926) points out that low temperatures are believed to cause the streaming of free water from the cells to the intercellular spaces. Formation of ice crystals in the intercellular spaces causes death mechanically. Cold hardy species, on the other hand, can bind their water into hydrophilic colloids and freezing does not occur at these temperatures. Saccharov (1930) states that cold hardiness of insects depends on the presence of a minimum quantity of water and the ability of the organism to accumulate fat. All hibernating stages of insects prepare themselves to withstand cold by reducing the quantity of free, easily freezable water in their tissues. These facts suggest several of the processes possibly involved in the adaptation of *Heterodera rostochiensis* to temperature extremes. Since both categories of cysts can exist at the same time, it is assumed that the winter condition is not an inherent periodic manifestation in the life-cycle. The winter condition, rather, is due to the adaptation of the larvae to lower temperatures. Another possibility is that the winter condition (i.e., dormancy) does exist as an integral part of the life-cycle, its degree, however, being influenced greatly by temperature. It is not yet known how long an exposure to a significantly higher or lower temperature is necessary for the nematode to readjust from one type to the other.

The data on the invasion of potato roots by *H. rostochiensis* larvae during the less active period and the data on the hatching of larvae between 40°F. and 100°F. are being augmented by work now in progress to determine the actual limits of activity of the nematode.

OVERWINTERING AS A FACTOR IN THE LIFE-CYCLE

An experiment was set up to determine whether or not overwintering, i.e., exposure to Long Island, N.Y., winter soil temperatures of 30°F–50°F, might play a role in the activation or maturing of larvae within cysts of *Heterodera rostochiensis*.

Pots containing potato seed pieces and sterile nematode-free soil were inoculated with large uncounted numbers of viable golden nematode larvae on September 16, 1949. The pots were kept in the greenhouse until December 1949. After the tops of the plants had died back, the pots were brought into the laboratory. At no time were the pots exposed to temperatures lower than 55°F. During April 1950, the nematode cysts, all of which had developed during the period between September and December 1949, were washed from the soil. Some were exposed to potato root leachings and others were placed in contact with potato seed pieces in nematode-free soil.

Subsequently, the dishes of cysts and leachings contained hatched larvae within two days and the seed pieces in infected soil bore white nematode cysts in early May 1950, indicating that soil temperatures between 30°F and 50°F under Long Island, N.Y. conditions play no part in the activation or maturing of larvae of *H. rostochiensis*.

HATCHING DURING WINTER

The life-cycle of *Heterodera rostochiensis* has been studied in detail by Chitwood and Buhrer (1946). They state that the course of the individual life-cycle, the period from embryonated eggs to embryonated eggs, may be not less than 38 days and does not exceed 48 days. In this study, Chitwood and Buhrer's observations were compared with the course of the life-cycle of the nematode

during the winter. Their findings are confirmed in the present study by the results obtained with the use of winter cysts.

Soil containing golden nematode cysts was dug from the laboratory's infested field on January 8, 1950. At that time, the top three inch layer of soil was frozen and the temperature of the underlying soil was 33°F to 34°F. The soil was allowed to thaw out overnight in an unheated shed and the cysts were washed out on January 10, 1950. The cysts were then combed through sterile nematode-free soil. Potato seed pieces of the Katahdin variety in which dormancy had been broken were planted in six inch pots in this soil on the same day. The pots were kept in benches in the greenhouse where temperatures fluctuated between 50°F and 65°F during the growing period.

On March 10, 1950, white cysts were observed at the exterior of the root balls. On March 23, 1950, 72 days after the planting date, the cysts were of a deep yellow color and contained embryonated eggs (Fig. 1). Four to five weeks may be allowed for the appearance of potato roots at the exterior of a 6-inch soil ball. Therefore, larvae from cysts near the exterior of the soil ball entered

FIG. 1.—Root ball of Katahdin potato plant with cysts of the golden nematode attached. Pictures taken March 23, 1950.

external roots growing out toward them in the four to five weeks after the planting on January 10. Yellow cysts containing embryonated eggs formed during a period of 37 to 44 days after the 4- to 5-week period.

In addition to the qualitative work mentioned above, a quantitative study showing that the nematode can reproduce at normal rates during the winter was made by the senior author of the present study (1949). Potato-seed pieces were exposed to known quantities of cysts in nematode-free soil in pots. The pots were kept in eight constant-temperature tanks in which temperatures were maintained by thermo-regulators. Each tank held eight pots containing cyst inocula of 1, 5, 16, 32, 450, 9000, 22,500, and 45,000 viable cysts, respectively. The rates of increase of new generation cysts resulting were inversely proportional to the quantity of inocula, the average rate of increase in pots with one viable cyst being 45.0 times the inoculum and the averge for the 45,000 cysts being 1.74 times the inoculum. The average rates of increase by tanks were as high as 13.6, with five of the tanks showing a rate of increase of 10.5 or better.

These observations serve as an indication that golden nematode cysts in the winter condition (from soil at freezing and near freezing temperatures) will infect potato roots when kept at temperatures approximating those of the normal growing season.

SUMMARY

Experiments were conducted which indicate that:

1. Cysts of the golden nematode, *Heterodera rostochiensis*, fall into two categories as far as susceptibility to methyl bromide fumigation and hot water treatments are concerned: the contents of winter cysts maintained at approximately 40°F. being less susceptible to control measures than those summer cysts maintained at 70°F.

2. Exposure of larvae within cysts to sublethal control measures may afterward cause an inhibition of the hatching response in potato-root leachings.

3. Golden nematode larvae will hatch out at temperatures as low as 40°F. when exposed to potato-root leachings and to tap water for 16 hours.

4. Larvae of 1-year-old cysts do not have to overwinter under Long Island, N.Y., field conditions in order to hatch out.

5. Larvae of cysts removed from field conditions in January 1950, when soil temperatures were at the freezing level, hatched out and infected potato roots during the same month under greenhouse conditions.

6. Hatching of golden-nematode larvae occurs under controlled temperatures during the winter months. Rates of reproduction compare favorably with those of natural infections during the summer.

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ENTOMOLOGY.—*Notes on Trichopodini (Diptera, Larvaevoridae), with description of a new parasite of cotton stainers in Puerto Rico.*[1]

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In Puerto Rico attempts were made in 1941 and 1942 to introduce from Peru a larvaevorid fly, *Acaulona peruviana* Townsend, as a parasite of cotton stainers, *Dysdercus* spp. Subsequent collections to determine whether that species had become established revealed the presence of an undescribed parasite, apparently a native species. In the taxonomic study of this new species, the New World genera of the tribe Trichopodini (*sensu* Townsend) were reviewed, and although a complete revision is not possible at this time, some results may be of aid to other workers in the future.

For convenience, the present paper is confined to the Trichopodini in the sense of Townsend. Certainly some genera of Townsend's Phasiini, however, are much closer to Trichopodini than to other phasiine genera, especially in the type of male and female genitalia (e.g., *Ectophasiops* Townsend). A similar distinction has been pointed out by Brooks and by Dupuis in recognizing two groups of genera within the Phasiini, based on reproductive habit and type of female genitalia. A natural grouping would seem to call for considerable rearrangement, with combination of parts or all of several tribes.

In almost all proposed genera of the Trichopodini either the fundamental structure is so similar or the characters so overlap that one must perforce either synonymize extensively or, with Townsend, construct unsatisfactory keys on variable and ineffective characters. One feature that seems not to have been used previously is the chaetotaxy of the scutellum, and this is so markedly different in two groups that it is a significant and highly useful initial division. In some cases, also, it is possible that differences in the form of the genitalia may justify generic recognition.

Complete citations of genotypes have been omitted for purposes of this contribution. They are given in full in Townsend (*Manual of myiology*, pt. 7: 9–35. 1938).

KEY TO THE NEW WORLD GENERA OF TRICHOPODINI

Key to Groups

1. Scutellum with basal scutellar bristles much longer than apicals, widely divergent, and inserted midway between basal corner of scutellum and apical bristles (Fig. 8); apical cell long petiolate.
Xanthomelanodes complex

Scutellum with basal bristles not obviously longer than apicals, directed posteriorly or curving mesad, and inserted quite near basal corner of scutellum (Fig. 9); apical cell open, closed at margin, or very short petiolate.. 2

2. Posterior tibia ciliate dorsally with a row of close-set, flattened bristles, which may or may not be obviously longer than diameter of tibia.....*Trichopoda* complex

Posterior tibia entirely without flattened bristles.....*Acaulona* complex

Xanthomelanodes Complex

1. Second segment of arista elongated, 3 times length of basal segment and 5 times it own breadth; third antennal segment elongated, 3 times length of second segment.
Xenophasia Townsend

First 2 segments of arista short; third antennal segment not elongated.
Xanthomelanodes Townsend

Trichopoda Complex

1. Postcoxal area, between hind coxae and first abdominal sternite, membranous and characteristically sunken or shriveled; front somewhat narrowed at vertex, the sides parallel on basal half, then suddenly diverging (Fig. 4)..... 2

Postcoxal area sclerotized, the lateral plates not distinctly separated by a sunken, membranous or weakened area; front not as

[1] Received September 15, 1950.

above, sides either subparallel throughout (Fig. 5), or widely diverging from vertex.. 4

2. Female with anal cerci widely separated basally, but with elongate, slender, converging apical portions, the eighth sternite polished black, triangular, with tip slightly recurved (Fig. 1); abdomen moderately slender and cylindrical in both sexes, habitus wasplike.....*Polistomyia* Townsend

Not so, the female cerci broadly approximated, without fingerlike prolongations; eighth sternite of female distally broadly rounded or truncate; habitus not wasplike..... 3

3. Anal cerci of female thick, posteriorly flattened structures ("heavy blocklike and obliquely truncate"—Townsend), flattened surfaces densely covered with fine short hairs arranged in rows (Fig. 3); eighth sternite of female short and broad, distally truncate; fused anal forceps of male not deeply notched distally, sloping basad from median process; wing moderately broadly hyaline along hind margin.....*Eutrichopoda* Townsend

Anal cerci not so, thin and platelike, sparsely haired (similar to Fig. 2); eighth sternite subquadrate, broadly rounded distally; fused anal forceps of male distinctly notched distally, with short thick median process and well-developed lateral angles; wing largely infuscated, including all or virtually all of discal and apical cells...*Trichopoda* Berthold

4. Only one strong sternopleural bristle, sometimes a much weaker anterior bristle; squamae gently rounded on hind margin; a "*Plecia*-counterfeit": black wings with clear areas in submarginal, first posterior, and discal cells.....*Bibiomima* B. B.

Two or three strong sternopleural bristles; squamae broadened and squared behind, hind margin straight or even slightly concave..... 5

5. Abdomen short-ovate, heavily pollinose; hind tibia with several strong bristles basad of flattened cilia in same row, the cilia short and only on distal third or less; hind tibia with 3 long anterodorsal and 3 long posterodorsal bristles; wing nearly clear, only faintly browned anteriorly.

Atrichiopoda Townsend

Abdomen generally longer; hind tibia not with bristles basad of cilia, but with isolated cilia and hairs that gradually decrease in size to base of tibia; 1 or 2 anterodorsal and posterodorsal bristles on hind tibia..... 6

6. Wing distinctively marked, broadly bright yellow midway of wing, the distal two-fifths to half of wing infuscated, especially on costal half.....*Syringosoma* Townsend

Wing otherwise marked, either entirely infuscated along costal third to half of wing, or whole wing more or less infuscated..... 7

7. Abdomen slender, cylindrical, the thorax also proportionately slender, the general aspect of fly like a slender *Cylindromyia*.

Tapajosia Townsend

Not so, the abdomen broader, often short and oval..... 8

8. Female genitalia as in Fig. 7, the eighth sternite elongated and strongly curved; median process of fused anal forceps of male knobbed apically, as seen in posterior view; wing of male not broadened basally.

Cylindrophasia Townsend

Female genitalia not so (unknown for *Homogenia*), the anal cerci broad and platelike, and eighth sternite short and neither strongly curved nor distally sinuate; males as far as known without knobbed median process on anal forceps.....*Homogenia* Van der Wulp (=*Euomogenia* Townsend)

Pennapoda Townsend

Platyphasia Townsend

Acaulona Complex

1. Dorsocentral bristles 2 + 3, long and strong, nearly subequal, occasionally anterior presutural and anterior postsutural shorter and weaker but still distinct..... 2

Not so, usually 1 + 1 strong bristles, or 1 + 2, anterior postsutural position without a bristle..... 4

2. With more or less distinct median marginal bristles on abdomen..... 3

No median marginal bristles present (at least in female, the only sex known); cerci broad and platelike (Fig. 2).

Melanorophasia Townsend (*s. str.*)

3. Body slender, abdomen usually very slender and tapering; female cerci broad, platelike (near Fig. 2); eighth sternite of female short and inconspicuous.

Xanthomelanopsis Townsend

Body broader, abdomen relatively shorter and broader; female cerci long, slender, and tapering; eighth sternite of female long, thin, polished, curving backward at tip.

Urucurymyia Townsend

4. No distinct median marginals on intermediate abdominal segments; female genitalia as in Fig. 6, the eighth sternite modified as a stout piercer.....*Acaulona* Van der Wulp (? = *Forcipophasia* Townsend)

Distinct median marginal bristles on at least some of abdominal segments..... 5

5. Squamae boot-shaped, strongly widened posteriorly, inner angle nearly a right angle, outer angle produced; fused posterior forceps of male with a dorsoventrally flattened median process, but not deeply notched laterad of the process (female unknown to me).

Euacaulona Townsend

Squamae not suddenly widened behind, outer margin nearly straight, hind margin weakly rounded; distal margin of fused posterior forceps of male deeply notched, and median process laterally compressed with enlarged tip slightly recurved; female genitalia as in *Xanthomelanopsis*, cerci broad and platelike (near Fig. 2)....*Itaxanthomelana* Townsend

XANTHOMELANODES COMPLEX

Genus **Xanthomelanodes** Townsend (1893)

Xanthomelana Van der Wulp, Tijdschr. Ent. **35**: 189. 1892. Preoccupied.

Xanthomelanodes Townsend, Can. Ent. **25**: 167. 1893.

Erythrophasia Townsend, Ins. Insc. Menstr. **4**: 127. 1917.

Townsend's replacement name was originally proposed on the ground that *Xanthomelana* was invalidated by its close similarity to *Xanthomelon* Martens (1860) in Mollusca, a position that was soon abandoned. Later (1908) Townsend stated that *Xanthomelana* was preoccupied by *Xanthomelana* Bonaparte (1850) in Aves, and still later (1938) that it was preoccupied by *Xanthomelana* Cabanis (1851) and Waterhouse (1889), also in Aves. Accordingly, Townsend used *Xanthomelanodes* in major works in 1897, 1908, 1927, 1936, and 1938; in the same period, *Xanthomelana* Van der Wulp was used by Coquillett (1897), Van der Wulp (1903), Aldrich (1905), Adams in Williston (1908), Coquillett (1910), and Curran (1934).

The references in Aves cited by Townsend have been examined in detail. In Bonaparte (Conspectus generum avium, **1**: 446–447, 1850, the genus *Euplectes* was divided into two parts, "*Pyromelanae*" with seven species and "*Xanthomelanae*" (p. 447) with four species. These indeed appear to be intended subgenera, though headed by names in the plural. The later references cited the second name as *Xanthomelana*, usually with a reference to Bonaparte, 1850 (Cabanis, Museum Heineanum, pt. 1: 177. 1851; Waterhouse, Index generum avium: 234. 1889; Horsfield and Moore, Cat. Birds Museum East India Co. **2**: 519, 1856–1858). In Cabanis and in Horsfield and Moore, *Xanthomelana* is cited in generic synonymy, and in the second work also in a specific synonymy as "*Euplectes* (*Xanthomelana*) *xanthomelana*." Even if the name is not considered available as of 1850, which some will accept, it must still be considered as dating from some one of the other works by citation in synonymy or by indication, and accordingly as preoccupying *Xanthomelana* Van der Wulp (1892).

It is quite probable that some of Van der Wulp's Mexican species will prove to be the same as some species in the following key. I have seen specimens from San Rafael, Veracruz, that I cannot distinguish from *arcuata* and *atripennis*, and one of Van der Wulp's species may be the same as *X. californica* Townsend. Of Van der Wulp's six species of *Xanthomelana*, *anceps* is the type of *Vanderwulpella* Townsend, and another species, *articulata*, appears to me from the description and figure to belong in *Xenophasia*, leaving four species still to be reckoned with in *Xanthomelanodes*.

Males predominate in the collections that I have seen. Of 108 available specimens of the four species included in the key, there are 81 males and 27 females.

KEY TO XANTHOMELANODES OF THE UNITED STATES

1. Legs predominantly yellow, femora entirely so or only obscurely browned at knee, tibiae partly yellow to brown; antenna almost entirely yellow..... *flavipes* (Coquillett)
   Legs predominantly black, tibiae and tarsi entirely so and femora black on distal half or more; antenna almost entirely black... 2
2. Front relatively narrow, at vertex 0.19–0.22 times the width of head (average 0.21) (eastern).....*arcuata* (Say)
   Front broader, at vertex 0.24–0.285 times head width (average 0.246 and 0.257 for the two species)..... 3
3. Cerci of male united, with median process distally; female cerci flat, platelike, short and acutely pointed, as in *arcuata* (cf. Fig. 11); typically 3 sternopleural bristles; usually 1 strong bristle below each vibrissa (western) *californica* Townsend
   Distal margin of united male cerci arcuate, without median process; platelike cerci of female elongate and slightly hooked at apex (Fig. 10); typically 2 sternopleurals; no strong bristles near the vibrissae (eastern) *atripennis* (Say)

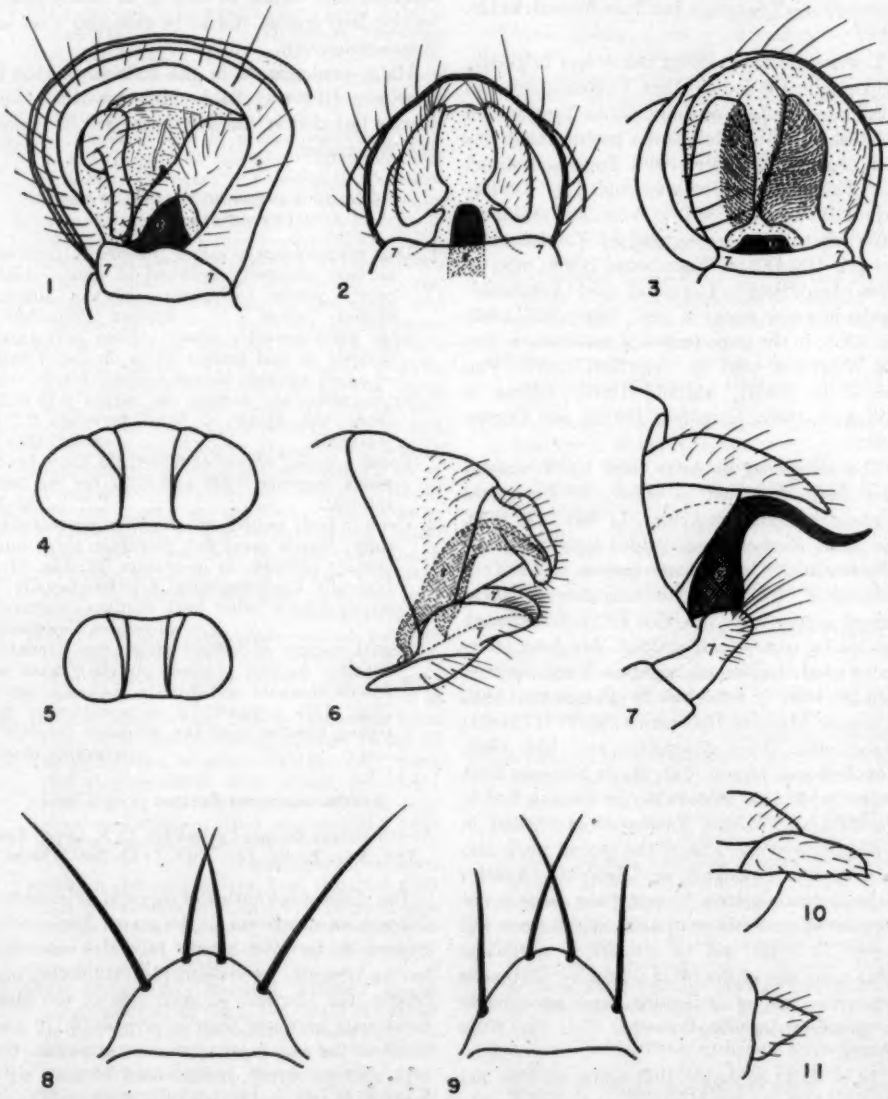
Xanthomelanodes flavipes (Coquillett)

Xanthomelana flavipes Coquillett, U. S. Dept. Agr. Div. Ent. Techn. Ser. Bull. 7: 72. 1897. (Mass.)

The distinct coloration of legs and antennae of this species stands out in the genus. The species appears to be most closely related to *arcuata*, having typically three sternopleural bristles, one bristle (the vibrissa) on each side of the face, front even narrower than in *arcuata* (0.176 and 0.186 in the two good specimens available, the type and paratype), united cerci of male with median process, and female cerci short and broad.

The few published records and available specimens are from the northeast (Mass., Vt., N. Y., Quebec).

Type male and paratype female (abdomen now missing), Horseneck Beach, Mass., August 4, 1896 (Hough). Type U. S. N. M. no. 3568. The male bears the original Museum type label and Coquillett's name label, both written by Coquillett. Inasmuch as Coquillett did not state the sex of the type, saying only "a specimen of each sex . . . Type No. 3568," some may not accept that as designating the holotype and may prefer to regard the present listing as lectotype designation.



FIGS. 1–11.—Trichopodini: 1–3, Posteroventral aspect (slightly lateral in 1 and 3) of female genitalia of *Polistomyia plumipes* (1), *Melanorophasia minuscula* s.str. (2), and *Eutrichopoda* sp. (3); 4, 5, dorsal aspect of head of *Trichopoda pennipes* (4) and *Acaulona peruviana* (5); 6, 7, side view (slightly posterodorsal in 6) of female abdomen of *Acaulona brasiliana* (6) and *Cylindrophasia simillima* (7); 8, 9, scutellum of *Xanthomelanodes arcuata* (8) and *Acaulona peruviana* (9); 10, 11, cercus of female. *Xanthomelanodes atripennis* (10) and *X. arcuata* (11).

Xanthomelanodes californica Townsend

Xanthomelanodes californica Townsend, Smithsonian Misc. Coll. **51**: 129. 1908.
? = *Stevenia pictipes* Bigot, Ann. Soc. Ent. France **42**: 254. 1888.

A small species, apparently closest to *X. arcuata*, with three sternopleurals and similar male and female terminalia, but with wider front and almost always with two pairs of bristles on the sides of the face.

Distribution: Western, Washington to California and east to Colorado, as far as known.

Stevenia pictipes Bigot from Washington Territory was placed by Coquillett (1897) as a synonym of *X. arcuata* (Say), but it might be either *californica* or *arcuata*.

Xanthomelanodes arcuata (Say)

Ocyptera arcuata Say, Journ. Acad. Sci. Philadelphia **6**: 173. 1829.

In addition to the narrow front, the species is characterized as follows: Typically three sternopleural bristles; abdomen strongly black marked, including the base, median dorsal spots on first two segments, and more of the third and fourth segments, in the female including nearly the whole tergite on the latter two segments; cerci of male united and with a median process distally; female cerci flat and platelike, short and acutely pointed (Fig. 11).

This species and *X. atripennis* have apparently been confused in many determinations because of some variation in color and in the number of sternopleural bristles. The two are quite distinct in both sexes, however, as noted in the key.

Townsend (Ins. Insc. Menstr. **4**: 126. 1917) placed *Wahlbergia atripennis* Townsend as a synonym of *arcuata*, after having regarded it in his earlier papers as a synonym of *X. atripennis* Say. From the lectotype of Townsend's species, I refer it back to *atripennis* Say (q.v.).

Distribution: Eastern, at least chiefly. Specimens before me are from Arkansas, Colorado, Illinois, Indiana, Kansas, Maryland, Massachusetts, Mississippi, New Hampshire, New Jersey, Texas, Virginia, Wisconsin. A headless specimen from San Rafael, Veracruz, Mexico, and a single specimen from Seattle, Wash. seem to belong here also.

Xanthomelanodes atripennis (Say)

Phasia atripennis Say, Journ. Acad. Sci. Philadelphia **6**: 172. 1829.
Wahlbergia atripennis Townsend, Proc. Ent. Soc. Washington **2**: 145. 1891. (D. C.).
Erythrophasia atripennis Townsend, Ins. Insc. Menstr. **4**: 127. 1917.

This species is sometimes confused with *X. arcuata*, as noted under that species, but is quite distinct in both sexes. The front is broader, at the vertex 0.245–0.285 times the width of the head (average 0.257); abdomen predominantly deep yellow to orange, sometimes with a dorsal row of obscure, indistinctly bounded brown spots, and occasionally discolored apically.

The history of the species has been somewhat confused by the use of the same specific name, *atripennis*, in three independent proposals, plus the fact that Townsend for many years considered his 1891 species a synonym of Say's species, and then later referred it to *arcuata* and redescribed Say's species as *Erythrophasia atripennis*. In my opinion all three are the same species. Types of both of Townsend's names are before me, and although Say's descriptions are inadequate from modern standards, the presence of only two common eastern species makes it possible to identify them with reasonable certainty.

I question the synonymy of *Tachina corythus* Walker, which Coquillett (1897) placed as a synonym of *X. atripennis* (Say). Walker's description states that the palpi of *corythus* are black and the wing dark gray with brown stripes along the veins, which does not sound like *Xanthomelanodes* at all.

Distribution: 38 specimens are before me from Arkansas, District of Columbia, Florida, Georgia, Maryland, New Jersey, and Virginia. One specimen from San Rafael, Veracruz, also seems to belong here. Most of the specimens were collected in August and September.

The four specimens of the original type series of *Wahlbergia atripennis* Townsend have been examined, one in the collection of the U. S. National Museum, and three from the Snow Collection, University of Kansas, lent through the courtesy of Dr. R. H. Beamer. All four are males. One in the Snow collection has been labeled as, and is hereby designated as lectotype, the other three as lectoparatypes.

Xanthomelanodes brasiliensis Townsend

Xanthomelanodes brasiliensis Townsend, Rev. Chilena Hist. Nat. **32**: 371. 1929.

In the type series before me I hereby designate as lectotype a male, Itaquaquecetuba, São Paulo,

Brazil, December 6; lectoallotype, May 6, and three lectoparatypes, May 21 (♂), May 29 (♂), June 3 (♀), all topotypic (C. H. T. Townsend). All specimens have Townsend name labels, and the lectotype and lectoallotype bear red labels as "Type," but in this case Townsend failed to specify which was the holotype, either by publication or label.

Trichopoda Complex

Trichopoda typica: Postcoxal area membranous

In this typical division of the *Trichopoda* complex the dorsal aspect of the head is characteristic, the front narrowed above with sides of front parallel on basal half, then suddenly diverging (Fig. 4); no outstanding median marginal bristles on intermediate abdominal segments, all marginal bristles being short and subequal; apical cell either short petiolate or closed at margin of wing, in either case the juncture with costa is slightly before the apex of the wing; hind crossvein more or less sinuate; hind tibia dorsally with long, flattened, scalelike cilia.

Genus **Trichopoda** Berthold

Trichopode (vernacular!) Latreille. Familles naturelles du règne animal: 498. 1825. (*"Thereva lanipes*, F.; ejusd., *t. plumipes*.")

Trichopoda Berthold, German translation of Latreille (1825), as "Natürliche Familien des Thierreichs mit Anmerkungen und Zusätzen von Dr. Arn. Ad. Berthold": 508. 1827. (*"Thereva lanipes*, Fab. *Thereva plumipes*, dess.")

Trichiopoda Latreille, Règne animal **5**: 512. 1829. (*Thereva plumipes* and *lanipes* of Fabricius, with several other species.)

Trichopodopsis Townsend, Journ. New York Ent. Soc. **21**: 148. 1913.

This genus has often been cited as *Trichiopoda* Latreille, but the first publication in proper Latinized form was by Berthold in translating Latreille (1825). The generic names in Latreille's work are in the vernacular, and cannot be accepted; it seems, therefore, that the name must be credited to Berthold (1827) with the spelling *Trichopoda*.

Townsend recognized *Trichopodopsis* for *T. pennipes* (Fabricius) and related species, but my studies have furnished no support for segregating these species from typical *Trichopoda* s. str.

The genus is widely distributed in the Nearctic and Neotropical Regions. Despite the commonness of some of the "species," there are still some puzzling problems of color pattern and possible erroneous association of sexes.

Genus **Eutrichopoda** Townsend

Eutrichopoda Townsend, Smithsonian Misc. Coll. **51**: 134. 1908.

The distinctive female cerci (Fig. 3) suggest that this group deserves separate status. The few specimens known to me are Neotropical except for one example from Panama City, Fla.

Eutrichopoda abdominalis Townsend, Rev. Chilena Hist. Nat. 32: 371. 1929. Lectotype female, here designated, "Mb. [Moyobama, Peru] 13.XI Rio Mayo Foliage." Lectoparatype, male, "Fls. Baccharis g Itq. 3.VI" [Itaquaquecetuba, São Paulo, Brazil, June 3, on flowers of *Baccharis genistelloides*]. Both in U. S. National Museum. The female was selected as the lectotype after studies showed that *Eutrichopoda* is probably a valid grouping based on the form of the female genitalia. The male is the one associated by Townsend, but I am not sure that the association is correct.

Trichopoda atypica: Postcoxal area closed

Genera of the *Trichopoda* complex, which are atypical with respect to the postcoxal area, also have the following characteristics: In dorsal aspect, the sides of the front either subparallel throughout (as in Fig. 5) or widely diverging from the base; abdominal segments generally with strong erect median marginal bristles (absent in *Atrichiopoda* and perhaps in some others; small in *Pennapoda;* may be smaller in females than in males of same species); apical cell open, either broadly or narrowly, occasionally closed at margin, and rarely (*Bibiomima*) petiolate, in any case the third vein curving posteriorly so that it ends precisely at the apex of the wing and not before (slightly atypical in *Platyphasia*); hind crossvein more or less sinuate; cilia on hind tibia usually short and confined to the distal third to half of the tibia, much less conspicuous than in the typical *Trichopoda*.

I suspect that some of the genera included here should be synonymized, but until the classification in this group is much clearer than at present it seems best to identify them as far as possible with present information. Several genera, such as *Atrichiopoda* and *Syringosoma*, have a rather distinctive habitus, but one can find little of real consequence for a generic characterization. *Cylindrophasia* has distinctive female genitalia (Fig. 7), but it would not be difficult to regard the structure as an unusually extreme development of some other genus. It seems indeed to be an

intermediate step toward the stout piercer, such as found in *Acaulona* (fig. 6). The male genitalia of *Tapajosia* are quite similar to those of *Cylindrophasia*, differing only in having the median process of the fused anal forceps extremely slender. Both have a cylindrical body, and the two may be synonymous. The female of *Tapajosia* is unknown to me. *Platyphasia* is distinctive in the male sex by having an abrupt right-angled bend in the median process of the anal forceps, as viewed in profile.

Acaulona tehuantepeca Townsend (Smithsonian Misc. Coll. 51: 130. 1908) from the holotype in the U. S. National Museum, is not an *Acaulona* but belongs here. The female genitalia agree with those of *Cylindrophasia*, and *tehuantepeca* is thus referred to that genus on present information.

Dallasimyia Blanchard (Rev. Argentina Ent. 2: 7. 1944) is not included in the key; it may be near *Cylindrophasia*, but it may also fall with the several concepts at the end of the key (*Homogenia* et al.).

Genus **Homogenia** Van der Wulp

Homogenia Van der Wulp, Tijdschr. Ent. **35**: 184. 1892.
Euomogenia Townsend, Smithsonian Misc. Coll. **51**: 132. 1908.

The relatively few specimens before me, with the broad wings typical of the genus, are all males, and one can suspect that the females may be narrow-winged and presently classified elsewhere. Even the broad wing of the male may not be a constant character, for a male from Argentina with typical genitalia, open apical cell, and broad front, has only a moderately wide wing.

Euomogenia Townsend is a synonym in my opinion; the anal angle is folded under in the type of the genotype, *E. lacteata*, so that the wing appears narrower, and the apical cell is closed at the margin of the wing. A later species, *E. dysderci* Townsend, has a very broad wing with apical cell widely open. I refer both species to *Homogenia*.

Euomogenia dysderci Townsend, Revista Ent. 7: 317. 1937. Lectotype male, here designated, Campinas, Brazil. Bears the name label and a red label "Type Ht. ♂," by Townsend.

ACAULONA COMPLEX

The genera that fall in this complex are extremely difficult to separate satisfactorily, yet there are a few features of the female genitalia that indicate some valid distinctions.

Genera **Xanthomelanopsis** and **Urucurymyia** Townsend

Xanthomelanopsis Townsend, Ins. Insc. Menstr. **4**: 126. 1917.
Urucurymyia Townsend, Revista Ent. **4**: 206. 1934.

These two genera, separated from others in the complex by the stronger chaetotaxy, have quite a different habitus from each other, and the different female genitalia also suggest that they are indeed distinct. As often the case in this tribe, however, it is difficult to find good generic characters. The peculiar appearance of the end of the abdomen in the two available females of *Urucurymyia*, giving an "urn-shaped" appearance (Townsend), may possibly be a distortion that is not necessarily typical. The narrow frontalia of the genotype of *Xanthomelanopsis*, *X. peruanus* Townsend, seems quite distinct, for the frontal stripe at its narrowest is only 1.6–1.9 times the parafrontal directly opposite, whereas in *Urucurymyia* the frontal stripe is approximately four times the parafrontal. However, a species of *Xanthomelanopsis* from Mexico is intermediate (proportion nearly three times), and that distinction is therefore weakened. The femae genitalia of *Xanthomelanopsis peruanus* are similar to the figure for *Melanorophasia* (cf. Fig. 2), though the cerci are nearly quadrate and the eighth sternite is short and inconspicuous.

It is perhaps worthy of special mention that *Xanthomelanopsis* is far removed generically from *Xanthomelanodes*, despite the similarity of name and the fact that the genotype of *Xanthomelanopsis* was originally described as *Xanthomelanodes*. The resemblance is only one of general habitus and common tribal characteristics.

Genus **Melanorophasia** Townsend

Melanorophasia minuscula Townsend

Melanorophasia minuscula Townsend, Revista Ent. **4**: 205. 1934. (Urucurytuba, Brazil; "3 ♂♂, 2 ♀♀".)

When the type series was examined for the purpose of selecting a lectotype, the writer at once noted that the abdomen of the so-called males did not have the usual appearance of males of this tribe, and it was suspected that all specimens in the type series were actually females. Dissection proved this to be the case. What was even more surprising, however, was that *two* different species of females were involved. The three "males" of Townsend have distinctly different genitalia from the two females, besides

which the former have entirely black legs, whereas the latter have the hind tibia basally and all femora toward the base yellow. A further difference is that the "males" have a full complement of dorsocentral bristles, whereas the females have a reduced number.

The lectotype of *M. minuscula* Townsend is the female, Urucurytuba, Rio Tapajós, Brazil, April 13 (Townsend), labelled by Townsend as "Ht ♂," and so designated in his *Manual of myiology* **7**: 22. 1938. Paratopotypes: 2 ♀ ♀, April 4 and 11. Female genitalia as figured (Fig. 2).

The other two specimens from the original type series, which do not seem to be congeneric with *M. minuscula* as here restricted, are left unnamed for the present. Until much more material is available and both sexes known throughout the tribe, and accordingly a generic classification can be better worked out, it would add nothing to describe these and guess at their generic position.

Regarding the genotype of *Melanorophasia*, it might be argued that in a case of this sort the genus is based on a composite species, and a later author is free to select either of the components as genotype. In my view, the genotype is automatically the named or monobasic species as finally restricted by a subsequent author. To be absolutely sure, in the present case, I hereby state that the genotype is *M. minuscula* as restricted above to the lectotype female.

The above actions were necessary to clear the nomenclature of the genus. Whether *Melanorophasia* deserves recognition at all, either as a genus or as a subgenus, is another matter and one upon which there is not sufficient information for judgment.

Genus **Euacaulona** Townsend

Euacaulona Townsend, Smithsonian Misc. Coll. **51**: 131. 1908.

The combination of shape of the squamae, distinct median marginal bristles, and type of male genitalia suggest that this may be a good genus, but material is limited. I have before me only the holotype of *E. sumichrasti* Townsend and two males of another species. Three females that key to this genus have genitalia unlike anything that I have seen in this tribe, and if they prove to be *Euacaulona*, their distinctness will be another argument in favor of recognition. These females are apparently not conspecific with any of the known males, however, and accordingly I cannot be sure of their position until I have males to associate with them, or known females of *Euacaulona* with which to compare.

It would also not be at all impossible that *Euacaulona* is merely based on males of *Acaulona* that are extreme in the bristling on the abdomen and in the width of the squamae.

Genus **Itaxanthomelana** Townsend

Itaxanthomelana Townsend, Rev. Mus. Paulista **15**: 214. 1927.

This genus cannot be keyed out in Townsend (Manual of myiology **3**: 50. 1936) because, contrary to the statement in his couplet 5 and again in the Manual (vol. 7, p. 21), there are no distinct median marginal bristles on the first abdominal segment, and the following two segments have median marginals and not a row of marginals. This is true in both sexes.

If the dorsocentral bristles were not considered significant, the presence of median marginals and the type of both male and female genitalia would key it to *Xanthomelanopsis*, but these two are quite distinct in general habitus. The female genitalia are approximately like those figured for *Melanorophasia* (cf. Fig. 2), the cerci somewhat broader and subquadrate and the eighth sternite broader and shorter. Despite the similarity of name, *Itaxanthomelana* is nearer to *Acaulona* than to *Xanthomelana*.

One specimen before me from Itaquaquecetuba, São Paulo, Brazil, was reared from *Dysdercus*.

Genus **Forcipophasia** Townsend

Forcipophasia Townsend, Revista Ent. **5**: 216. 1935. (Brazil).

This genus was described from a single female having "hypopygium forcepslike." If I interpret the description correctly, however, this is the same type of genitalia found in *Acaulona* (Fig. 6), and the suspicion is strong that *Forcipophasia* may be merely the female of species of *Acaulona*, perhaps based on a specimen in which the genitalia were especially protruding and distinct. Without knowledge of the type, I cannot place it.

Genus **Acaulona** Van der Wulp

Acaulona Van der Wulp, Biologia Centr.-Amer., Zool., Dipt., **2**: 4. 1888.

Acaulona s. str. has the female eighth sternite modified as a strong, black, rather large and conspicuous, piercing sternotheca, strongly recurved so that in profile the distal half is at right angles to the basal portion, deeply grooved above and ending acutely between the approximated tips of the anal cerci (Fig. 6); anal cerci narrow, somewhat elongated, with their apices approximated forcepslike, and approaching or overhanging the seventh sternite so that as seen in profile the cerci and the seventh sternite also appear forcepslike. This is the characteristic form of the female genitalia as found in *A. brasiliana*, *A. peruviana*, *A. erythropyga*, n. sp., and in Mexican material determined by Townsend as *A. costata* Van der Wulp. This type of genitalia seems to be an intermediate step to the phasiine type with strong piercer found in such genera as *Hyalomya*, *Alophorella*, and *Phasiomyia*.

For those who may be tempted by the admittedly close similarity of habitus and general morphology to synonymize some of the other genera of this complex under the older *Acaulona*, it may be noted that *Xanthomelanopsis*, *Melanorophasia s. str.*, and *Itaxanthomelana* have quite a different type of female genitalia, with broad, flat, platelike cerci and the eighth sternite thin, flat, apically rounded and not recurved (Fig. 2). *Urucurymyia* and *Melanorophasia* (atypical part) are slightly different from the last three genera, but are certainly much closer to them than to *Acaulona*. The female of *Euacaulona* is not known to me. Since the type of genitalia found in *Xanthomelanopsis* et al. indicates that the eggs are laid on the body of the host rather than inserted as by *Acaulona*, this difference in reproductive habit suggests that the "*Acaulona* complex" of this paper is not a natural grouping. However, with so many points still unknown from lack of reared material, positively associated sexes, etc., it seems futile to revise further at this time. If the present arrangement proves useful in aiding identification, or in avoiding misidentifications, it will have served its immediate purpose.

Acaulona brasiliana Townsend

Acaulona Townsend, Revista Ent. 7: 316. 1937. (Campinas, São Paulo, Brazil; parasite of *Dysdercus*.)

The abdomen, as Townsend clearly indicated, is characteristically marked, being mainly dark yellow with a median dorsal row of more or less distinct brown to blackish triangles, the apices directed cephalad. The species is close to *A. peruviana* and it is difficult to find concrete differences. In the series of the two before me, *brasiliana* averages slightly larger, and females are usually darker, though some females have entirely yellowish abdomen. The frontal stripe is slightly wider, two to three times the width of the parafrontal.

Five paratypes (4 ♂♂, 1 ♀) are before me, as well as about two dozen specimens from São Paulo, Brazil, and Bompland (Misiones Territory), Chaco, and Santiago del Estero, Argentina, all reared from *Dysdercus*.

Acaulona peruviana Townsend

Acaulona peruviana Townsend, Est. Exp. Agr. Soc. Nac. Agraria (Lima, Peru), Bol. 1: fig. 3 and p. 7. 1928.

Species with pale habitus, predominantly yellow; scutellum chiefly yellow, usually only narrowly infuscated basally; abdomen mainly yellow with a narrow median brown to blackish stripe on the dorsum, widening slightly on the posterior margin of each tergite beyond the first to form a subtriangular spot, a pattern more pronounced in the female than in the male; tergites 4 and 5 of male conspicuously pollinose, the others more or less shining; in female the fifth tergite polished, fourth large and pollinose, and some pollen on middle of segments one to three, decreasing anteriorly; all coxae yellow; hind femora yellow on basal third to two-thirds, mid on basal fourth to half, fore narrowly yellow at base if at all, legs darker in females than in males.

Parafrontalia relatively broad, and frontalia correspondingly narrow, compared with other species, the relative width of frontalia to parafrontalia across apex of former 1.7 to 1.75 times in the males and 1.8 to 2.2 in the females; female genitalia approximately as figured for *A. brasiliana* (cf. Fig. 6).

Length, 4 to 6.5 mm.

Neotype, male, "Tmb R. [Río Tambo, Peru], 31.V Fls. Euphorbia." Neallotype, same data, May 30. Neoparatypes: 11 (8 ♂♂, 3 ♀♀), same data, May 29, 30, 31; 1 ♀, Sullana, Peru, February 17, 1912; 1 ♀, Chincha, Peru, April 5, "Fls. Euphorbia"; 1 ♀, Zomate, Peru, November 18, "Fls. Telanthera sp."; 1 ♀, Cañada Zamán, Peru, February 14, 1912, "Fls. Ph. flava"; 1 ♀, "Peru"; 1 ♂, Chapairá, Peru, May 21, 1911 (all collected C. H. T. Townsend). The Neallotype

bears Townsend's own determination label as "*Acaulona peruviana* TT ♀."

Type, U. S. N. M. no. 60133.

It is essential to fix the name of this species because it is an important parasite of *Dysdercus* in Peru, and attempts have been made to introduce it elsewhere. Townsend never published a formal description of it, but the name was nevertheless validated in connection with the full-page figure published by Townsend in the Boletin cited above. Additional information published at that time located the species in the coastal valleys of Peru as a parasite of *Dysdercus*.

Recent attempts to recover the species after its introduction into Puerto Rico in 1941 and 1942 have so far been negative, though a new and apparently native species has been discovered (see *A. erythropyga*). It is possible that *Acaulona* spp. are host specific, or if not strictly so, at least the Puerto Rican species of *Dysdercus* may be too distantly related to the Peruvian species for the parasites to transfer. There are no species of *Dysdercus* common to Peru and Puerto Rico, according to my colleague Dr. R. I. Sailer.

Neotype designation is not yet recognized by the International Rules, and there will probably be considerable opposition. Certainly the practice is open to abuse, and to merit recognition some clear standards should be insisted upon and rigidly adhered to. If the designation of holotypes and lectotypes has any value and reason for being, much the same value and reason seem to apply also to the designation of neotypes. The major difference is that for neotypes a much graver responsibility rests with the taxonomist who presumes to select a standard of reference (neotype) to replace the original standard for the species (holotype, or by subsequent action, lectotype).

It is my conviction that a neotype should be required to satisfy all of the following requirements, as far as possible: (1) Agreement with the original description, with any redescriptions of the holotype, and with any known figures, photographs or notes on the type; (2) recognition of and agreement with a previous published restriction, or with the oldest if there are several, even though the restriction was not accompanied by a lectotype or neotype designation in a present-day sense; (3) topotypic material, to the extent that the locality is known, and also in the same stratum for paleontological material; (4) for neozoology, the same time of year, same sex, and same host plant or animal as the original, if any or all of these are known; and (5) neotype deposited in the same collection as the original, or in whatever collection or institution the original collection is presently located. In other words, a neotype must and should duplicate the original conditions as nearly as possible.

It would usually be impossible to find an author's original but nontypical material, or perhaps even other material determined by him as the species in question, and thus it would be impracticable to insist on these requirements, but if such material existed, it would certainly be highly desirable and appropriate to utilize that as a neotype series.

The neotype series selected above for *Acaulona peruviana* fulfills all of the above requirements. Of particular importance is the fact that the present series is composed of specimens collected and identified by Townsend himself, and quite possibly intended to be the type series, but for some reason left undescribed in a formal way.

Acaulona tehuantepeca Townsend

Acaulona tehuantepeca Townsend, Smithsonian Misc. Coll. **51**: 130. 1908. (Mexico.)

The type of this species, a female, has short, flattened cilia on the hind tibia and hence will fall in the *Trichopoda* complex rather than in *Acaulona*. Even if the evidence of the flattened cilia is disregarded or overlooked, the species still cannot be placed in *Acaulona*, for the female genitalia are like those of *Cylindrophasia*, to which genus the species has been referred elsewhere in this paper.

Acaulona erythropyga, n. sp.

♂, ♀. A typical *Acaulona*, agreeing with generic diagnosis of Townsend (Manual of Myiology 7: 9, 1938) except in darker color, narrower frontalia, and slightly developed abdominal macrochaetae.

Predominantly blackish, in contrast to the yellow to orange habitus of other known species. *Head* with occiput, frontalia chiefly, and antenna black, tip of palpus infuscated, face and cheek yellow with whitish pollen, and parafrontal black in ground color but whitish to pale yellow pollinose. *Thorax* black with whitish-gray pollen, that on mesonotum outlining the usual pattern of three broad black stripes. *Abdomen* chiefly black, in the female tergites 4 and 5 and the hypopygium bright reddish yellow and strongly

contrasting with the rest of the abdomen, in the male these tergites black dorsally and sometimes laterally but usually more or less reddish at least on the extreme sides of tergites, male hypopygium reddish. *Legs* black; claws brown with black tips; pulvilli yellow. *Wing* lightly infuscated throughout, slightly darker on anterior (costal) two-fifths; squama white; halter light yellow.

Width of front at vertex 0.31–0.35 times the width of head; width of frontalia just above antennal bases 2–2.2 times the width of a parafrontal at the same level; third antennal segment slightly longer than the second, as 5:4; sternopleural bristles two, with a weak third in some specimens; marginal bristles on abdominal segments slightly developed, with a pair of widely separated median marginals that are weakly distinct, more so in males than in females; apical cell of wing closed at margin or very narrowly open.

Genitalia: Characteristic *Acaulona* type, the female approximately as figured for *A. brasiliana* (Fig. 6); anal forceps of male with straight, slightly tapered median process.

Length, 5–6 mm.

Holotype, male, Guayanilla, Puerto Rico (W. Gaud; reared from *Dysdercus andreae* (L.), P.R. No. 2578). Allotype, and 12 paratypes (7 ♂♂, 5 ♀♀), same data. "Emerged November 26 to January 25 in R.[earing] Cage 78, which contained numerous host adults and nymphs from fruits and twigs of *Thespesia populnea* along Road 36 at Km. 4.2, near where *Acaulona peruviana* Tns. and *Hyalomya chilensis* Macq. had been liberated in 1941."

Other paratypes (all Puerto Rico): 2 (♂, ♀), Guayanilla, September 21, 1945 (H. K. Plank); 1 ♂, Guayanilla (Gaud), emerged August 11, 1949, from *D. andreae*; 2 (♂, ♀), Guanajibo, near Mayagüez, August 5, 1947, reared from *Dysdercus sanguinarius* Stål; (3 ♂♂, 3 ♀♀)*, Guayanilla (Gaud), emerged September 26–30, 1949 from *D. andreae*; 1 ♀*, Guayanilla (Gaud), emerged September 26, 1949 from *D. andreae*; 2 ♂♂*, Guayanilla (Gaud), emerged November 9 and 28, 1949 from *D. andreae*; 4 (2 ♂♂, 2 ♀♀)*, Guayanilla (Plank), emerged December 22, 1949–January 16, 1950 from *D. andreae*.[2]

Type, U. S. N. M. No. 60134. Paratypes will also be deposited in the British Museum (Nat. Hist.), American Museum of Natural History, and H. J. Reinhard collection.

[2] Specimens marked with asterisk were reared from hosts collected as noted for the topotypic series.

ENTOMOLOGY.—Sigmactenus, *a new genus of flea from the Philippines.*[1] ROBERT TRAUB, Major, MSC.[2] (Communicated by C. W. Sabrosky.)

The Chicago Natural History Museum Expedition to the Philippines, 1946–1947, which operated under the direction of Harry Hoogstraal, collected a most interesting flea, which is here described as a new genus.

Family LEPTOPSYLLIDAE

Subfamily PECTINOCTENINAE

Sigmactenus, n. gen.

Near *Pectinoctenus* Wagner, but with upper end of comb of head distant from antennal groove and curved backwards; labial palpi extending much below apex of maxillary palpi; frontal tubercle absent; first segment of female antenna shorter than club.

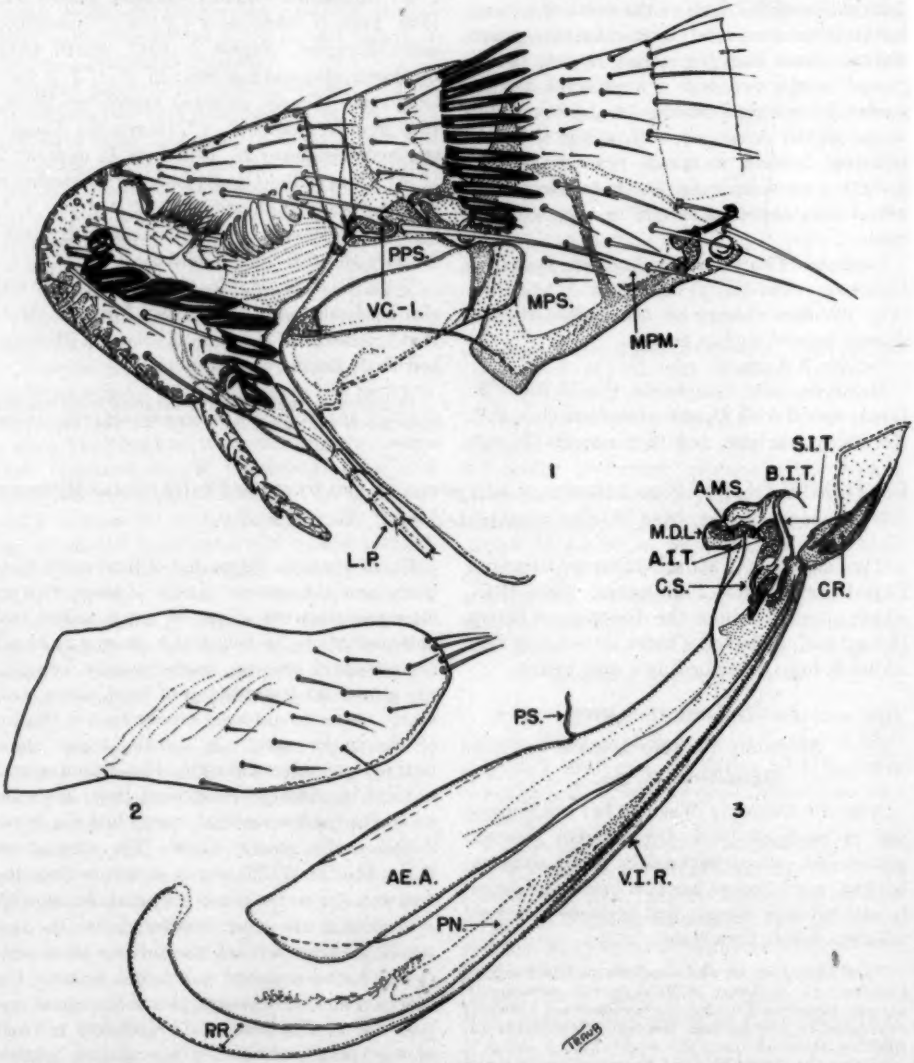
Caput fractum. Upper end of head comb relatively near the anterior margin of head; with an interspace between apices of upper spines and antennal groove, in female this space is as broad as these spines are long, shorter in male. Vestigial eye moved far towards top of head, along with comb; nearer to antennal groove than is the tip of the upper spine. In female, upper spine farther from anterior margin of head than second or third by virtue of translucent base; less so in male; the comb somewhat resembling the letter S (hence the generic name). The area above the comb (frons) different in structure from the area anterior to the comb (clypeus). Frons with a horizontal row of six bristles; below the row two larger ones between the anterior three bristles or between second and fourth bristles; the row continued downwards as a submarginal clypeal row of thin bristles. Immediately in front of the comb a downward row of two bristles, one at level of midpoint of comb. Internal in-

[1] Published under the auspices of the Surgeon General, U. S. Army, who does not necessarily assume responsibility for the professional opinions expressed by the author. Received September 12, 1950.

[2] From the Army Medical Service Research and Graduate School, Washington, D. C.

crassations of upper part of clypeal area extending nearly to comb or somewhat beyond comb. Postantennal area with three rows of bristles. Pedicel with bristles short, at most with only one bristle reaching beyond apex of club. Antennal groove not extending into propleuron. Labial palpi reaching to three-fourths or four-fifths of forecoxae. First vinculum received in sinus of prosternosome. Pronotal comb not extending below the spiracle; separated from the prosternosome by a marginal lobe of the notum. Dorsolateral tibial bristles forming a comb as in *Leptopsylla*. Typical abdominal segments with apical teeth and with two rows of bristles. Male with three antepygidial bristles; female with four. Male eighth tergum large; eighth sternum well-developed. Aedeagal crochets large, apical, articulated, recalling *Leptopsylla*. Third apodemal rod arising from ninth sternum.

Genotype: *Sigmactenus werneri*, n. sp.

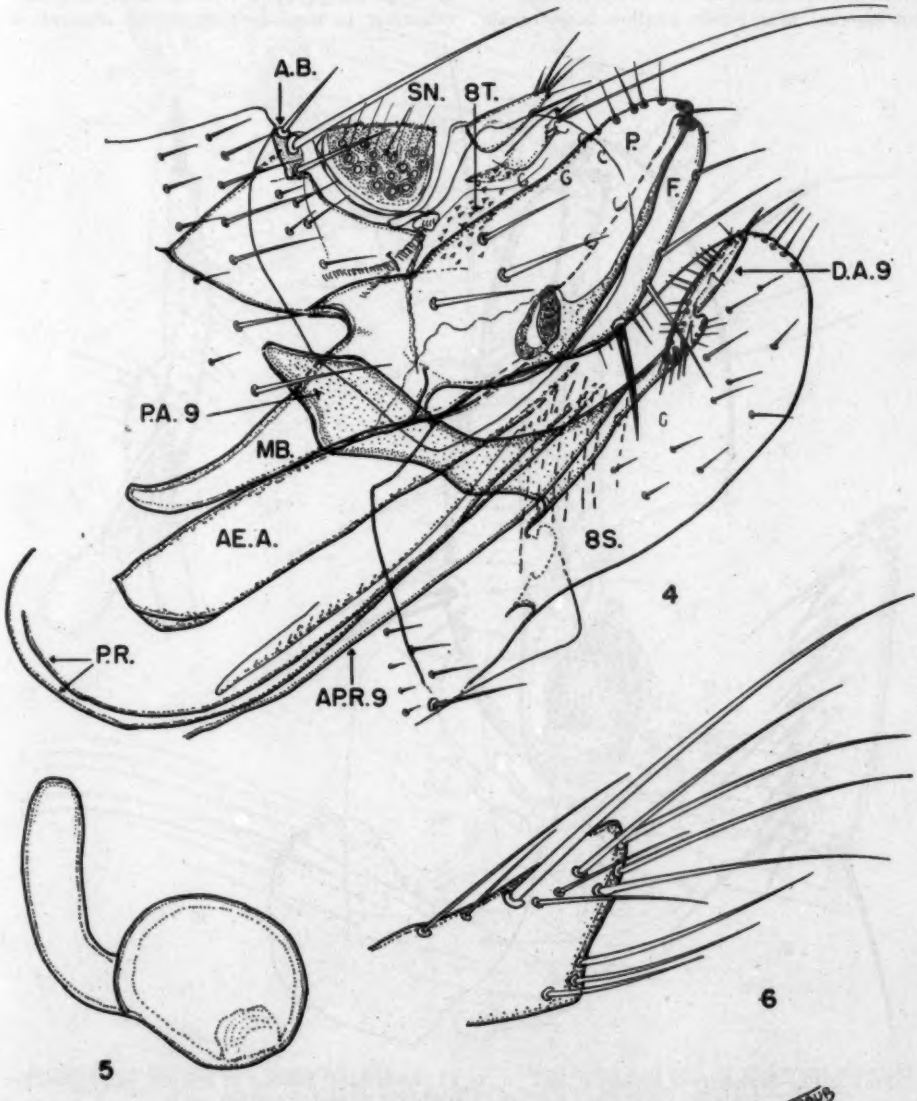


FIGS. 1–3.—*Sigmactenus werneri* n. gen., n. sp.: 1, Head and part of thorax, male; 2, eighth sternum, male; 3, aedeagus.

Sigmactenus werneri, n. sp.

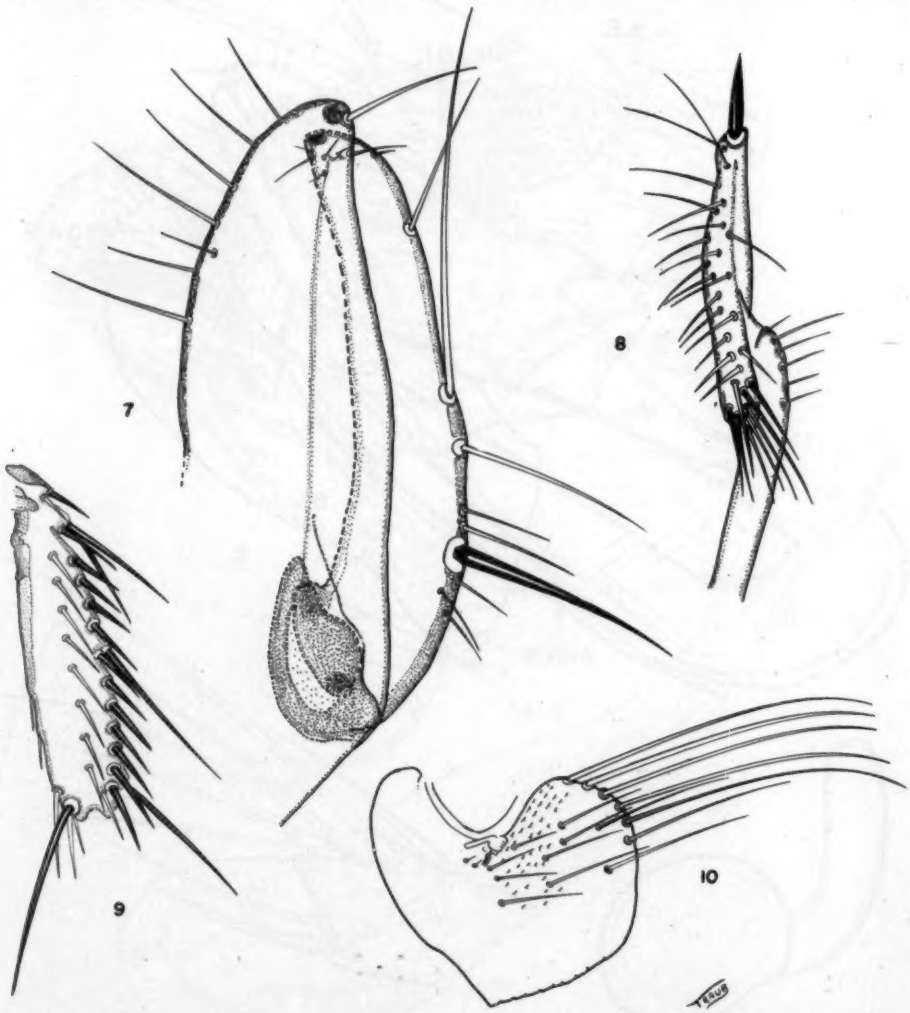
Figs. 1–14

Types.—Holotype male and allotype female ex *Podogymnura truei* (a shrew). Philippine Islands, Mindanao, Davao Province, east slope of Mount McKinley, elev. 6,300 feet, coll. H. Hoogstraal, September 10, 1946, (R.T. #6524). Deposited in Chicago Natural History Museum. One paratype male with same data in author's collection. Two paratype females with same data but 12 September (R.T. #6525). Four females ex *Rattus*, loc. cit. but elev. 6,200 feet, September 28, 1946, coll. M. Celestino for the C.N.H.M. Philippines Expedition (R.T. #6528). Paratype females in U. S. National Museum and British Museum (Tring).

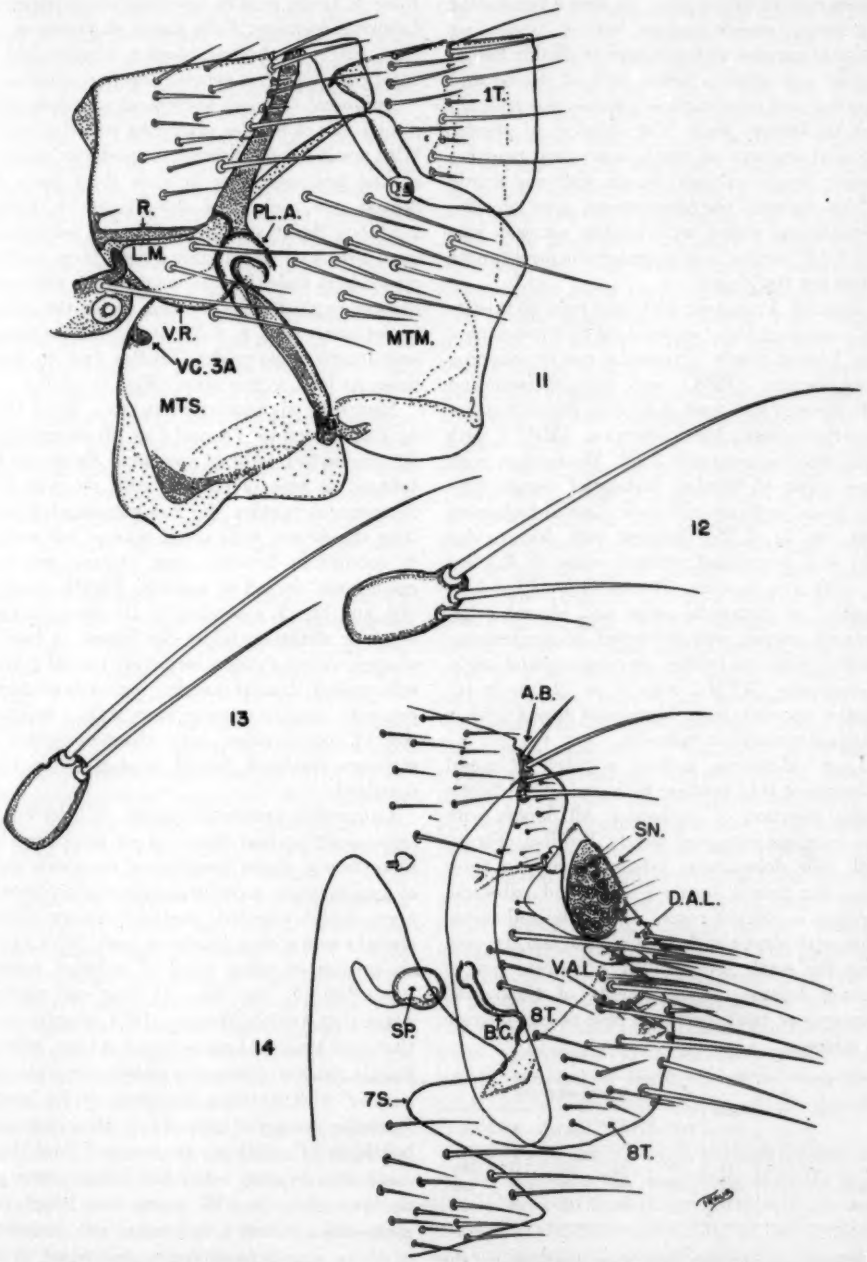


FIGS. 4–6.—*Sigmactenus werneri* n. gen., n. sp.: 4, Modified abdominal segments, male; 5, spermatheca; 6, ventral anal lobe, female.

Description.—MALE AND FEMALE, HEAD (Fig. 1): Submarginal clypeal row of six to eight small thin bristles, excluding the much smaller bristles at level of top of comb of head. Upper long bristle below frons row of six inserted at level of upper part of first ctenidial spine; lower bristle longer, inserted at level of ventral margin of this spine. A long bristle about halfway between uppermost and lowermost spines of comb, but inserted near comb; another large bristle almost directly below this but near margin of head. What appears to be a setal pore inserted near base of second spine. This pore present in all specimens, but no bristle visible in any. Spines of comb variable in number, ranging from 7 to 10, 8 and 9 being the most frequent number. The holotype has eight on one side and nine on the other; two paratypes also have one more spine on one side than the other. Maxillary lobe extending to near apex of second segment of



FIGS. 7–10.—*Sigmactenus werneri* n. gen., n. sp.: 7, Immovable process of clasper, and exopodite; 8, distal arm of ninth sternum; 9, protibia; 10, eighth tergum, male.



FIGS. 11–14—*Sigmactenus werneri* n. gen., n. sp.: 11, Metathorax and part of abdomen, male; 12, anal stylet (variation); 13, typical anal stylet; 14, modified abdominal segments, female.

five-segmented labial palpi. As seen when resting in antennal groove, apical half of male first antennal segment with scattered small thin lateral bristles and with a dense tuft of dorsal and marginal and submarginal bristles; this tuft absent in female. Male with bristles of second antennal segment all short, none even reaching halfway length of club; female with one bristle of this segment reaching beyond apex of club. Postantennal region with bristles on each side 4(5)-4-5-6, the first row irregular; the penultimate of last row the longest.

THORAX: Pronotum with two rows of bristles and a comb of about eleven long thin spines on a side. Lowest bristle of pronotal row overlapping proepisternum (*PPS.*) very long. Mesonotum with three or four rows of bristles, the first one or two incomplete. Mesepisternum (*MPS.*) with eight bristles arranged 3-3-2. Metanotum with three rows of bristles. Metanotal flange with two apical teeth on each side. Lateral metanotal area (fig. 11, *L.M.*) distinct; with dorsal ridge (*R.*) well sclerotized, ventral ridge (*V.R.*) less so; with two bristles. Pleural arch (*PL.A.*) at junction of metanotal ridge and pleural ridge, strongly convex, well-developed. Metepisternum (*MTS.*) with one bristle, near dorsocaudal angle. Metepimere (*MTM.*) with 11 or 12 (rarely 10) bristles on each side. Metanotal flange with a small apical tooth on each side.

LEGS: Metacoxa lacking a patch of mesal spinelets or thin bristles; with one lateral bristle above insertion of trochanter. All femora with one marginal subapical bristle. Protibia (Fig. 9) with nine dorsolateral bristles (including three from the paired bristles) short and subequal, forming a distinct comb. Mesotibia and metatibia with eleven such bristles in comb. In each case the comb preceded by a sparser row of thinner bristles. Measurements of tibiae and segments of tarsi (petiolate base deleted) shown in microns:

Leg	Tibia	Tarsal segments				
		1	2	3	4	5
Pro-	179	60	72	61	47	100
Meso-	288	173	126	85	58	100
Meta-	357	321	178	118	63	100

Not only are the legs very long, particularly the hind legs, but they are narrow: ratio of metatibial length to breadth is more than 4 to 1; similar ratio in metatarsal segment I is 7 to 1. None of tarsal bristles reaching beyond apex of following segment. Fifth tarsal segments of all legs with four lateral plantar bristles and a basal pair displaced ventrally to near midline.

ABDOMEN: Typical abdominal segments with second row of bristles extending below spiracles. With small subdorsal teeth on posterior margins of first few segments; in male these teeth arranged (on each side) 2-2-2-1-(1); in female 2-2-(1)-1. Basal sternum with one ventromarginal bristle. Typical sterna with three bristles on a side in male, four in female. Male with middle antepygidial bristle about thrice the length of the others (Fig. 4, *A.B.*); in female, the second and fourth antepygidial bristles two to three times as long as the other (Fig. 14, *A.B.*).

MODIFIED ABDOMINAL SEGMENTS, MALE (Fig. 4): Eighth tergum (*8T.* and Fig. 10) extending as far caudad as middle of process of clasper, as far ventrad as base of clasper; with six very long dorsocaudal bristles, the last somewhat shorter than the others; with about nine or ten median or submedian bristles, none ventral; spiculose caudad and dorsad of spiracle. Eighth sternum (*8S.* and Fig. 2) extending as far distad as apex of ninth sternum and as far dorsad as base of clasper; dorsal margin biconvex; caudal margin subrounded; ventral margin proximally shallowly concave, distally convex; apex with a marginal row of four bristles; with about seventeen or eighteen scattered lateral bristles, none truly marginal.

Immovable process of clasper (*P.* and Fig. 7) subconical; portion distad of an imaginary line immediately above insertion of exopodite twice as long as broad; anterior margin slightly sinuate; apex almost rounded; posterior margin almost straight and with a bristle at apex; with five or six bristles on apical third of anterior margin. Exopodite (*F.* and Fig. 7) long and narrow, suggesting *Foxella* Wagner, 1929, slightly more than four times as long as broad at base; anterior margin shallowly concave; posterior margin subparallel with anterior for most of its length. Posterior margin of exopodite with a long stout bristle or subspiniform at proximal third; three small thin bristles below the subspiniform and two just above it; with a very long bristle near midpoint; a shorter bristle below this, but distad of those near subspiniform, and equal in size to another bristle at apical third. Exopodite with five to seven short thin apical or subapical bristles, some mesal.

Manubrium (*MB.*) about 3½ times as long as broad at base; dorsal and ventral margins fairly straight; dorsal margin, in the main, making an angle of about 40° with ventral margin; apex slightly upturned, not pointed.

Proximal arm of ninth sternum (*P.A. 9*) markedly expanded at apical fourth, the ventral margin particularly convex here; narrowing rapidly towards apex, which is narrowed; remainder of ventral margin shallowly biconcave, the proximal concavity the smaller; remainder of dorsal margin evenly convex. Distal arm of ninth sternum (*D.A. 9* and Fig. 8) much narrower than proximal arm, only about one-third as broad as narrower portions of proximal arm; more than seven or eight times as long as broad; divided into a basal and apical half, the latter bearing a conspicuous apical spiniform, a fringe of 7 or 8 basal stout heavy bristles and about 17 bristles on anterior (morphologically dorsal) margin or on dorsal portion, the most apical two the longest; basal half with about six small bristles near apex of posterior margin.

Aedeagal apodeme (*AE.A.* and fig. 3) slightly longer than aedeagus proper, but the characteristic apical sclerites crowded in the small end chamber. Proximal spur (*P.S.*) present. Crescent sclerite (*C.S.*) convex, identifying position of obscured sclerites of apodemal strut. Median dorsal lobe (*M.D.L.*) short, convoluted, associated with a lateral sinuate sclerite (*A.M.S.*) on each side. Sclerotized inner tube (*S.I.T.*) nearly vertical, slightly sinuate. With a sclerotized narrow band of the inner tube (*B.I.T.*) extending distad of apex of sclerotized sheath of inner tube. Armature of inner tube (*A.I.T.*) represented as an irregular somewhat bilobed sclerotized structure along dorsal border of *S.I.T.* Crochets (*CR.*) very large, consisting of a ventral subfusiform, apically acuminate, well sclerotized portion and a larger cleaver-shaped, lateral, lightly sclerotized portion; lateral lobes inapparent, but no specimen available for dissection. Ventral intramural rod (*V.I.R.*) present.

Sensilium (Fig. 4, *SN.*) flat, longer than broad, with about 17 pits visible on a side. Dorsal lobe of proctiger with about four subapical bristles. Ventral lobe of proctiger with about four apical and one or two subapical longish bristles and three or four small subapical bristles.

FEMALE (Fig. 14): Seventh sternum (*7S.*) caudally biconcave, the sinus between the lobes deep; the lobes slightly longer than broad at base, somewhat narrowed or even pointed apically; the dorsal lobe in some specimens almost as long as ventral lobe, at times the two sides of one specimen differ in this respect. Ventral lobe of seventh sternum with three or four long dorsomarginal bristles, the lowest near the apex, and ten to twelve smaller, more proximal bristles, one of these bristles near base of sinus sometimes as long as marginal ones. Eighth tergum (*8T.*) with many bristles, commencing with two dorsal rows (one incomplete) of small bristles above spiracle; with four well-developed submedian bristles, that below tenth segment large; with a row of four large bristles ranging from ventral anal lobe to ventral margin of segment; with 9 to 13 smaller bristles in irregular rows preceding these large bristles; ventral half of caudal margin with four or five bristles, the longest one at shallow sinus of segment; with three or four mesal curved bristles near ventral anal lobe. Dorsal anal lobe of proctiger (*D.A.L.*) with two or three subapical longish bristles and about four small ones forming an apical fringe, with five or six tiny hairs at anteroventral angle. Anal stylet (Fig. 13) not quite twice as long as broad; dorsal and ventral margins somewhat convex; with two long apical bristles, one very long; with an indication or vestige of base of a subapical dorsal bristle; one specimen with an additional well-developed subapical bristle (Fig. 12). Ventral anal lobe (*V.A.L.* and Fig. 6) with dorsal margin shallowly concave; caudal margin sinuate; with three dorsomarginal bristles, the last very long; caudal margin with three bristles near dorsal angle and three near ventral; with three median bristles in dorsocaudal angle. Spermatheca (*SP.* and Fig. 5) with head longer than broad; dorsal margin strongly convex, ventral margin shallowly concave, anterior and posterior margins rounded; tail narrow, longer than head. In allotype (drawn) the spermatheca may be somewhat distorted in mounting; in other specimens, particularly in series R.T. #6528 (cf. below), the tail is slightly recurved over the head. Bursa copulatrix (*B.C.*) well-developed, vermiform except for dilated head.

Remarks.—This is a highly variable species; as can be seen from the description, even the two sides of an individual may vary in such usually established characters as number of genal spines and shape of female seventh sternum. The series from *Rattus* show slight differences in chaetotaxy and in the seventh sternum, but these differences cannot properly be evaluated without additional specimens.

The species is named for Floyd Werner, entomologist, who served under Harry Hoogstraal on the Chicago Natural History Museum Philippines Expedition and who has collected some very interesting ectoparasites.

I wish to thank Dr. Karl Jordan, J. H. E. Hopkins, and F. G. A. M. Smit, of the British Museum, for reviewing the manuscript.

LIST OF ABBREVIATIONS

A.B.	Antepygidial bristle.
AE.A.	Aedeagal apodeme.
A.I.T.	Armature of inner tube of aedeagus.
A.M.S.	Apical or apicomedian sclerites of aedeagus.
AP.R.9	Apodemal rod of ninth sternum.
B.I.T.	Narrow band of inner tube extending distad of apex of sclerotized inner tube.
B.C.	Bursa copulatrix
CR.	Crochet of aedeagus.
C.S.	Crescent sclerite.
D.A.L.	Dorsal anal lobe.
D.A.9	Distal arm of ninth sternum.
F.	Exopodite or movable finger.
L.M.	Lateral metanotal area.
L.P.	Labial palpi.
MB.	Manubrium.
M.D.L.	Median dorsal lobe.
MPM.	Mesepimere.
MPS.	Mesepisternum.
MTM.	Metepimere.
MTS.	Metepisternum.
P.	Immovable process of clasper.
P.A.9	Proximal arm of ninth sternum.
PL.A.	Pleural arch of metathorax.
PN.	Penis.
PPS.	Proepisternum.
P.R.	Penis rods.
P.S.	Proximal spur of aedeagus.
R.	Dorsal ridge of lateral metanotal area.
S.I.T.	Sclerotized inner tube.
SN.	Sensilium.
SP.	Spermatheca.
V.A.L.	Ventral anal lobe of proctiger.
VC.1	First vinculum.
VC.3A.	Accessory link below third vinculum.
V.I.R.	Ventral intramural rod.
V.R.	Ventral ridge.
7S.	Seventh sternum.
8S.	Eighth sternum.
1T.	First tergum.
8T.	Eighth tergum.

ZOOLOGY.—*A new species of* Terebripora *from the Pacific* (*Bryozoa Ctenostomata*).[1]

JOHN D. SOULE, Allan Hancock Foundation, University of Southern California. (Communicated by Waldo L. Schmitt.)

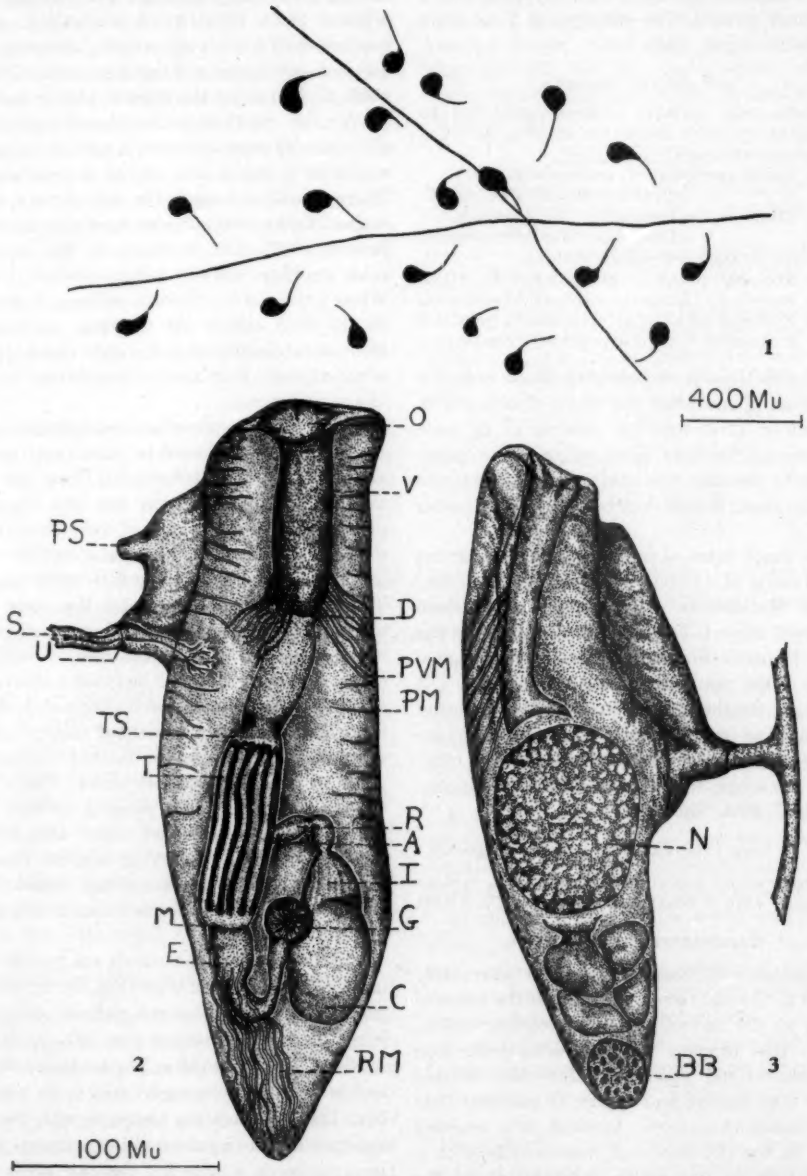
As early as 1920 Canu and Bassler lamented the lack of information available concerning the anatomical details of burrowing bryozoans, but until the publication by Marcus in 1938 of "Bryozoarios Perfuradores de Conchas" the anatomy and ctenostomatous affinities of the burrowing Bryozoa remained completely unknown. In this work Marcus discussed and figured the anatomy of *Terebripora ramosa* d'Orbigny, 1847, and *Spathipora sertum* Fischer, 1866. No further work pertaining to the anatomy of this type of burrowing Bryozoa appeared until 1946, when Silen published the results of his research on two new families of burrowing Bryozoa, the Penetrantiidae and the Immergentiidae. The following year, 1947, Silen adequately pointed out the futility of basing the specific classification of burrowing Bryozoa entirely upon their zoarial tracings made in the shells of mollusks. With regard to this, Silen pointed out how some of the species previously assigned to the genus *Terebripora* merely on the basis of shell tracings could as easily be assigned to *Immergentia* and that some of the *Spathipora* may well be *Penetrantia*. In so far as superficial external appearances are concerned, determination of the genera and the species is hopeless. On the basis of shell markings confirmed by anatomical studies, the burrowing Bryozoa until now fell into two groups: the *Terebripora-Immergentia* type and the *Spathipora-Penetrantia* type. *Terebripora ramosa* d'Orbigny readily fits into this pattern.

With the publication of Silen's work it therefore becomes necessary to amend the description of the genus *Terebripora* d'Orbigny, 1847, to include basic anatomical details which will serve to distinguish this genus from the genera *Spathipora*, *Immergentia*, and *Penetrantia*, respectively.

Genus **Terebripora** d'Orbigny, 1847

Zoaria stolonate, consisting of primary stolons joined to the zoids by secondary stolons, the point of union with the zoids being nearly midway between the distal and proximal extremities, but

[1] Contribution from the Allan Hancock Foundation. Received August 16, 1950.



FIGS. 1–3.—*Terebripora comma*, n. sp.: 1, Shell surface, showing a portion of a zoarium and the characteristic shape of the apertures, dried specimen; 2, same, showing anatomy of the autozoid; 3, same, showing anatomy of the kenozoid. (A-anus; BB-brown body; C-caecum; D-diaphragm; E-esophagus; G-gizzard; I-intestine; M-mouth; N-embryo; O-orifice; PM-parietal muscle; PS-pseudo stolon; PVM-parieto-vaginales muscle; R-rectum; RM-retractor muscle; S-stolon; T-tentacle; TS-tentacle sheath; U-septum; V-vestibule.) Drawings by Dorothy F. Soule.

always closer to the distal end. Polypide with a prominent gizzard. The genotype is *Terebripora ramosa* d'Orbigny, 1847.

KEY TO THE GENERA

1. Zoaria with primary stolons connected to zoids by short secondary stolons, entering near distal end.
   a. Zoids operculated, gonozoid present (Penetrantiidae) *Penetrantia*
   b. Zoids not operculated, no gonozoid (Terebriporidae) *Terebripora*
2. Zoaria lacking secondary stolons.
   a. Stolonal point of attachment at distal extremity (Immergentiidae) *Immergentia*
   b. Stolonal point of attachment at proximal extremity (Terebriporidae) *Spathipora*

Actually there is considerable doubt as to the soundness of including the genus *Spathipora* in the family Terebriporidae because of its wide anatomical differences. However, until the opportunity to examine the zoids of the *Spathipora* presents itself, I believe it best to let the matter rest.

The exact dates of publication of the various installments of d'Orbigny's "Voyage dans l'Amerique Meridionale" have long been a controversial subject. Fortunately, the library of the Allan Hancock Foundation retains the original covers of the installments bound separately. The date 1847 for the genus *Terebripora* was selected following an examination of the original blue wrapper (cover) which contained among other items the zoophyte section and bears the printed date 1847, 89th "livraison."

KEY TO THE SPECIES WITH KNOWN ANATOMY

Autozoid with 12 tentacles.....*T. ramosa*
Autozoid with 8 tentacles.....*T. comma*

Terebripora comma, n. sp.

Diagnosis.—Successive zoids are alternately placed to the right and to the left of the primary stolon at the end of a short secondary stolon. From the primary stolons occasional thin branches extend upward to the shell surface where they emerge and appear as minute round dots. Autozoid elongate, tapering to a rounded point at the proximal end, occasionally with a pseudostolonal connective point distal to the actual secondary stolonal junction. Tentacle number of the autozoid is 8. Embryos develop in numerous kenozoids.

Description.—In *Terebripora comma* is found the first variation from the usual *Terebripora-Immergentia* type of surface tracings as delineated in the introductory passage. The zoarium in its original state prior to decalcification of the mollusk shell has a very striking resemblance to the surface tracings of *Spathipora sertum* Fischer, 1866, as figured by the original author and later by Marcus. So close is this resemblance that if the anatomy were unknown it could be identified as Fischer's species with no risk of contradiction. There is also a remarkable resemblance to the original figure of *Spathipora longirima* Canu and Bassler, 1923. The openings of the immersed zoids are close without being crowded (Fig. 1). When a trace of the filiform stolon is in evidence on the shell surface the openings are found in alternate arrangement to the right and to the left of the stolonal path and have a distinct comma-like appearance.

In a zoarium removed by decalcification of the shell, the zoids are found to be of two types, the autozoids and the kenozoids. These zoids are alternately arranged along the thin threadlike primary stolon by means of very short lateral secondary stolons, each having a septum at the junction point where the stolon meets the zoid. These secondary stolons enter the zoids about midway between the distal and proximal extremities, but always nearer to the distal. Occasionally on both types of zoids will be found a short extension that appears to be a second or pseudostolonal connective point, but is without attachment to a secondary stolon and is located immediately distal to the true secondary stolon. The primary stolons, with a diameter ranging between 11.5 μ and 14 μ have additional septa separated by stolonal intervals of varying lengths. From the primary stolons an occasional thin branch occurs, extending upward to open as a minute circular dot on the shell surface.

Anatomically, the autozoids are typical of the usual ctenostomatous type (Fig. 2). In the polypide is found a prominent globular gizzard. In length the autozoids range from 320 μ to 350 μ and in width from 57 μ to 80 μ. The tentacles are short and in serial sections were found to be 8 in number. The autozoids are elongate, with the distal aperture bluntly square and the proximal portion terminating in a tapering rounded point. None of the distinct spherical brown bodies so much in evidence in the *Penetrantia* and the *Immergentia* were found.

The numerous kenozoids, formerly functional autozoids now modified for reproduction, have a prominent large oval embryo of uniform diameter

measuring 69 μ at maturity (Fig. 3). The kenozoids vary in length from 299 μ to 334 μ and in width from 75 μ to 80 μ. Structures that may be incipient brown bodies were found in a few of the kenozoids in the proximal tip below the degenerate polypide.

Terebripora comma differs from *T. ramosa* d'Orbigny in the following respects: (1) The tentacle number of *T. comma* has 8 tentacles, *T. ramosa* 12, *fide* Marcus; (2) *T. comma* has pseudostolonal connective points; (3) the zoaria of *T. comma* does not conform to the usual *Terebripora-Immergentia* surface pattern as is found in *T. ramosa*.

Holotype.—AHF no. 53.

Repository.—Allan Hancock Foundation, University of Southern California, Los Angeles, Calif.

Type locality.—Accession no. 403 T 112, southwest of Newport, Calif. trawl 112, 18 fathoms, June 16, 1915. In the shell of a dead *Polinices draconis*.

Additional distribution.—Hancock station no. 1937–50, 1 mile northwest of the west end of Anacapa Island, Calif., lat. 34° 01′ 32″ N., long. 119° 27′ 30″ W.; depth 38-43 fathoms; bottom sandy; March 24, 1950; in dead shell of *Epitonium* sp.?

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ZOOLOGY.—*A new* Orconectes *from the Pontchartrain watershed in Louisiana and Mississippi (Decapoda: Astacidae)*.[1]

GEORGE HENRY PENN, Tulane University of Louisiana. (Communicated by Fenner A. Chace, Jr.)

The new crawfish described here apparently is limited in distribution to the cool-water, sand- and gravel-bottomed creeks and rivers that make up the Lake Pontchartrain watershed in southeastern Louisiana and adjoining parts of Mississippi. I take great pleasure in naming this new species in honor of my close friend and authority on North American crawfishes, Dr. Horton H. Hobbs, Jr., of the University of Virginia.

Orconectes (Orconectes) hobbsi, n. sp.

Diagnosis.—Rostrum with prominent lateral spines, upper surface deeply concave, no median carina. Areola very narrow, its length averaging 24 times its width. Thoracic region of cephalothorax about 28 percent of the total length of the cephalothorax. Male with hooks on ischiopodites of third pereiopods only. First pleopod of form I male terminating in two long, setiform, deeply split rami: central projection corneous and recurved at right angles to the shaft; mesial process troughlike just proximad of the apex, recurved at about 90° angle to shaft. Annulus ventralis of female immovable, surface contours and sinus as in Fig. 8; may be either right- or left-handed.

Holotypic male, form I.—Body subovate, not depressed (Figs. 1, 2). Abdomen narrower than cephalothorax. Width of cephalothorax at widest point slightly greater than depth at same point.

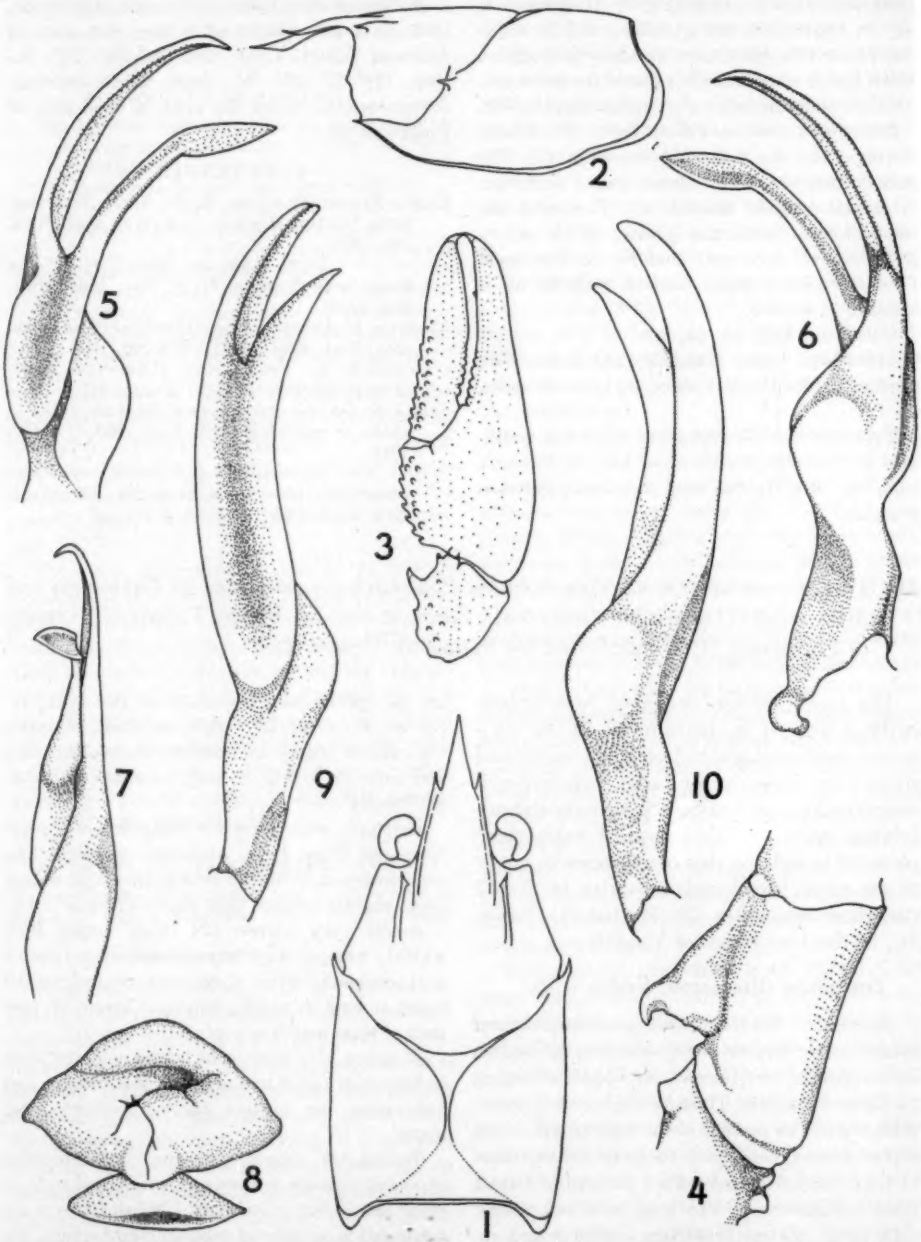
Areola very narrow (24 times longer than width), without any punctations in narrowest part; cephalic portion of cephalothorax about 2.6 times as long as areola; length of areola 28 percent of total length of cephalothorax.

Rostrum with prominent lateral spines; widest at base, margins raised, more or less straight and converging; no median carina. Acumen long, acute.

Postorbital ridges prominent, terminating cephalad in acute corneous spines. Branchiostegal spine small, but prominent. Cephalic groove interrupted in vicinity of cephalolateral spines, the latter very prominently developed.

Cephalic region of telson with two spines in each caudolateral angle, the more lateral spine about twice the length of the mesial one.

[1] Aided by a grant from the University Council on Research of the Tulane University of Louisiana. Received June 23, 1950.



FIGS. 1–10.—*Orconectes* (*Orconectes*) *hobbsi*, n. sp.: 1, Dorsal view of cephalothorax of holotype; 2, lateral view of cephalothorax of holotype; 3, upper surface of chela of holotype; 4, hook on ischiopodite of third pereiopod of holotype; 5, mesial view of first pleopod of holotype; 6, lateral view of first pleopod of holotype; 7, caudal view of first pleopod of holotype; 8, annulus ventralis of allotype; 9, mesial view of first pleopod of morphotypic male, form II; 10, lateral view of first pleopod of morphotypic male, form II.

Antennules of usual form.

Antennae broken, approximately equal to total length of crawfish on other specimens. Antennal scales extending slightly beyond apex of rostrum; lateral margin straight or nearly so, swollen, terminating in a strong spine; lamellar portion narrow; greatest width of scale about one-third of total length of scale.

Chela somewhat depressed; palm inflated; inconspicuous setigerous punctations present over most of chela; inner margin of palm with several irregular rows of small tubercles (Fig. 3). Both fingers terminating in short corneous tips bent toward each other. Small tubercles on basal parts of opposable margins of fingers. With medium length tuft of hairs at base of immovable finger. In life both fingers dark blue over basal three-fourths, followed by a narrow white band and bright red apex.

Hooks on ischiopodites of third pereiopods only; hooks prominent, greater than half the diameter of the base of the ischiopodite, apex recurved (Fig. 4).

First pleopod reaching anterior margin of coxopodite of third pereiopod when abdomen is flexed. Apex terminating in two distinct rami which are separated for most of their lengths (Figs. 5–7). Central projection corneous, long, setiform and recurved caudad at a 90° angle to the shaft. Mesial process swollen just proximad of the tip and trough-like, recurved caudad at about a 90° angle to the shaft.

Allotypic female.—Quite similar to the holotype in most respects. Annulus ventralis immovable, subspindle-shaped, with greatest length in transverse axis. Sinus originates near cephalodextral margin, extends irregularly sinistrad across annulus beyond midline, and turns abruptly caudodextrad back to the midline, then caudad on an irregular, somewhat zigzag course to the midcaudal margin of the annulus (Fig. 8).

Morphotypic male, form II.—Differs only slightly from the holotype. Hooks on ischiopodites of third pereiopods much reduced. First pair of pleopods longer, reaching to anterior margin of coxopodite of second pereiopod when abdomen is flexed; without corneous tips on terminal rami; rami separated for less than one-fourth of their lengths (Figs. 9, 10). Central projection stout, slightly excavated along caudo-mesial margin, tip recurved caudad at less than a 45° angle to the shaft. Mesial process shorter than central projection, stout, tip recurved caudad at less than a 45° angle to the shaft.

Measurements.—HOLOTYPIC MALE: Cephalothorax, height 9.0, width 10.0, length (on mid-dorsal line) 21.0 mm; areola, width at narrowest point 0.25, length 6.0 mm; rostrum, width at base 2.8, length 6.6 mm; abdomen, length to tip of telson 23.0 mm; right chela, length of inner margin of palm 4.2, greatest width of palm 5.6, thickness of palm 3.9, length of outer margin of hand 14.7, length of movable finger 9.0 mm; antennal scale, length of lateral margin 5.6, greatest width 1.9 mm. ALLOTYPIC FEMALE: Cephalothorax, height 9.1, width 10.5, length on mid-dorsal line 22.5 mm; areola, width at narrowest point 0.25, length 5.95 mm; rostrum, width at base 2.8, length 8.1 mm; abdomen, length to tip of telson 24.0 mm; right chela, length of inner margin of palm 4.2, greatest width of palm 5.6, thickness of palm 3.5, length of outer margin of hand 14.4, length of movable finger 8.4 mm.

Type locality.—The holotype and allotype were collected on November 7, 1948, in the headwater creek of Bayou Lacombe at St. Tammany (6 miles north of Lacombe on Louisiana State Highway 187), St. Tammany Parish, La. This is a shallow, spring-fed, sand-bottomed creek about 20 feet wide flowing through cutover longleaf pine flats which are only slightly above sea level (alt. 10 feet). The banks are eroded and shaded by mixed hardwoods and pines. Vegetation is scarce in the water, but drifts of fallen branches and leaves behind sandbars make abundant hiding places for crawfishes and other aquatic invertebrates.

The morphotypic male, form II, was collected July 10, 1948, in the Tchefuncte River, 4 miles west of Covington, St. Tammany Parish, La. This is a creek slightly larger than but essentially similar to the one at the type locality.

Disposition of types.—The holotypic male, the allotypic female, and the morphotypic male, form II, are deposited in the United States National Museum, nos. 90952, 90953, and 90954, respectively. From the paratypic series, one male, form I, one male, form II, and one female are deposited in the Museum of Comparative Zoology, and similar series are deposited in the collections of the Academy of Natural Sciences of Philadelphia, the University of Michigan Museum of Zoology, the collection of Dr. Horton H. Hobbs, Jr., of the University of Virginia, and

the American Museum of Natural History. One male, form I, 6 males, form II, 19 juvenile males, 13 females, and 13 juvenile females are retained in the Tulane University collections.

Specimens examined.—Sixty-six paratypes of *Orconectes hobbsi* in addition to the three types have been examined from the Lake Pontchartrain watershed in Louisiana and Mississippi. Arranged by parishes (Louisiana) and counties (Mississippi) these records and disposition of the specimens are as follows: *LOUISIANA:* EAST FELICIANA: Comite River, 1 mile west of Clinton, III-28-49, F. R. Cagle (TU 990); LIVINGSTON: Amite River, 2 miles south of Weiss, VII-3-48, G. H. Penn and M. H. Penn (U. M. M. Z.); ST. HELENA: Amite River, 1 mile west of Darlington, VII-3-48, G. H. Penn and M. H. Penn (TU 574); Tickfaw River, 1 mile northeast of Liverpool, VIII-13-48, G. H. Penn and M. H. Penn (TU 775); ST. TAMMANY: Tchefuncte River, 4 miles west of Covington, VII-10-48, A. Hagan (morphotype, U. S. N. M.; A. N. S.; A. M. N. H.); Slidell; VI-3-37, P. Viosca and H. B. Chase (TU P.624) headwaters of Bayou Lacombe at St. Tammany, VI-13-37, P. Viosca and G. H. Penn (TU P-334; A. N. S.); same locality, I-9-38, P. Viosca and G. H. Penn (A. N. S.; U. M. M. Z.); same locality, VII-10-48, A. Hagan (TU 620, M. C. Z.); same locality, XI-7-48, L. L. Ellis (holotype and allotype, U. S. N. M.; TU 852; M. C. Z.); same locality, XI-1-49, G. H. Penn (H. H. Hobbs); same locality, VI-2-50, G. H. Penn and E. W. Smith (TU 1974). *MISSISSIPPI:* AMITE: Beaver Creek, 2 miles east of Gloster, VII-4-48, G. H. Penn and M. H. Penn (TU 581); PIKE: Bogue Chitto River, 12 miles east of McComb, VII-5-48, G. H. Penn and M. H. Penn (TU 586).

Relationships.—*Orconectes hobbsi* is clearly a member of the *Virilis* section of the genus on the basis of the long, setiform, deeply split, recurved rami. Its affinities within the section are not entirely clear at present. The structure of the first pair of pleopods of the form I male and of the rostrum makes it appear closest to *O. palmeri* (Faxon) and *O. creolanus* (Creaser), but it differs from these species in having an open areola, though this is extremely narrow.

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